OIPE JCT05 AUG 29 2005 PATENT & TRADEMARK OFFICE

08-31-05

Docket No. 00SC033US7

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor : John A. Higgins
U.S. Patent No : 6,762,661 B1
Issued : July 13, 2004
Serial No. : 09/675,696 Examiner: Dean O. Takaoka
Filed : Sept. 29, 2000 Group Art Unit: 2817

Title: SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS AND METHOD FOR SWITCHING

Attn: Certificate of Correction Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL REQUEST FOR CERTIFICATE OF CORRECTION OF APPLICANT'S MISTAKE

Sir:

Certificate
SEP 06 2005
of Correction

Transmitted herewith please find the following:

- Request for Certificate of Correction of Applicant's Mistake,
- Certificate of Correction form PTO/SB/44 (one page),
- Correct Formal Drawings (six sheets),
- Copy of Jan. 8, 2003 Office action,
- Copy of May 5, 2003 Amendment with informal corrected drawings,
- Copy of July 14, 2003 Office action, and
- Copy of specification submitted Sept. 29, 2000.

Check No. 24346 in the amount of **$100.00** is enclosed to cover the required fee for the Certificate of Correction of Applicant's Mistake. If any additional fee is required, the Commissioner is authorized to charge Deposit Account No. 11-1580. A duplicate of this transmittal is enclosed for the convenience of the Patent and Trademark Office.

Respectfully submitted,

Dated: 8/29/05

Jaye G. Heybl
Registration No. 42,661
Attorney for Applicant

KOPPEL, JACOBS, PATRICK & HEYBL
555 St. Charles Drive, Suite 107
Thousand Oaks, California 91360
(805) 373-0060
U:\JJ1\ROCKWELL\00SC033US7 Cert. of Correction Transmittal 8-16-05.doc

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express ~~First-Class~~ mail in an envelope addressed to: Attn: Certificate of Correction Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on:

August 29, 2005
Date

Jenny Jirkovsky

SEP 07 2005

PATENT

Docket No. 00SC033US7

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor : John A. Higgins
U.S. Patent No : 6,762,661 B1
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Title: SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS AND METHOD FOR SWITCHING

Attn: Certificate of Correction Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR CERTIFICATE OF CORRECTION OF APPLICANT'S MISTAKE

Sir:

This is a request for a Certificate of Correction to correct a mistake that was made with the submission of incorrect formal drawings for the above issued patent. A set of formal drawings were submitted with the filing of the patent on September 29, 2000. In the January 8, 2003 Office action, the Examiner objected to the drawings because they did not comply with some of the reference signs mentioned in the description. In the May 8, 2003 response to the Office action, we submitted an informal set of corrected drawings that conformed to the Examiner's recommendations. In the subsequent July 14, 2003 Office action, the Examiner approved the proposed drawing corrections submitted May 8, 2003, and requested a formal set of the approved drawings. Upon payment of the Issue Fee, the original set of formal drawings was mistakenly submitted and not the corrected set of formal drawings as approved by the Examiner. As a result, the incorrect drawings were published in the patent. A Certificate of Correction is respectfully requested to replace the existing drawings with the correct formal drawings that were approved by the Examiner.

In addition, we respectfully request a certificate of correction be issued for two minor typographical errors in the above issued patent. The first typographical error is due to applicant's mistake and was inadvertently submitted to the PTO in the specification. On the

title page in the Abstract, in line 1, "A shutter switch is disclosed the is placed in the path…", please delete "the" and replace it with --that--. The correct wording of the phrase is as follows: "A shutter switch is disclosed that is placed in the path…"

The second typographical error was made by the PTO. In column 7, line 16, delete "snorting" and replace it with -- shorting --. A copy of the patent application filed Sept. 29, 2000 is enclosed for your reference.

Respectfully submitted,

Date: 8/29/05

Jaye G. Heybl
Registration No. 42,661
Attorney for Applicant

KOPPEL, JACOBS, PATRICK & HEYBL
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(805) 373-0060
U:\JJ1\ROCKWELL\00SC033US7 Certificate of Correction 8-15-05.doc

SEP 07 2005

PTO/SB/44 (04-05)
Approved for use through 04/30/2007. OMB 0651-0033
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.
(Also Form PTO-1050)

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,762,661 B1

APPLICATION NO.: 09/675,696

ISSUE DATE : July 13, 2004

INVENTOR(S) : John A. Higgins

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Replace drawings sheets 2, 3, 5, 6, 7, and 8 with the corresponding replacement drawings sheets.

On the title page in the Abstract, line 1 replace the word "the" with the word -- that --. The correct phrase should be: "A shutter switch is disclosed that is placed in the path of a ..."

Column 7, line 16, replace "snorting" with -- shorting --.

MAILING ADDRESS OF SENDER (Please do not use customer number below):

KOPPEL, JACOBS, PATRICK & HEYBL
555 St. Charles Dr., Suite 107
Thousand Oaks, California 91360

SEP 07 2005

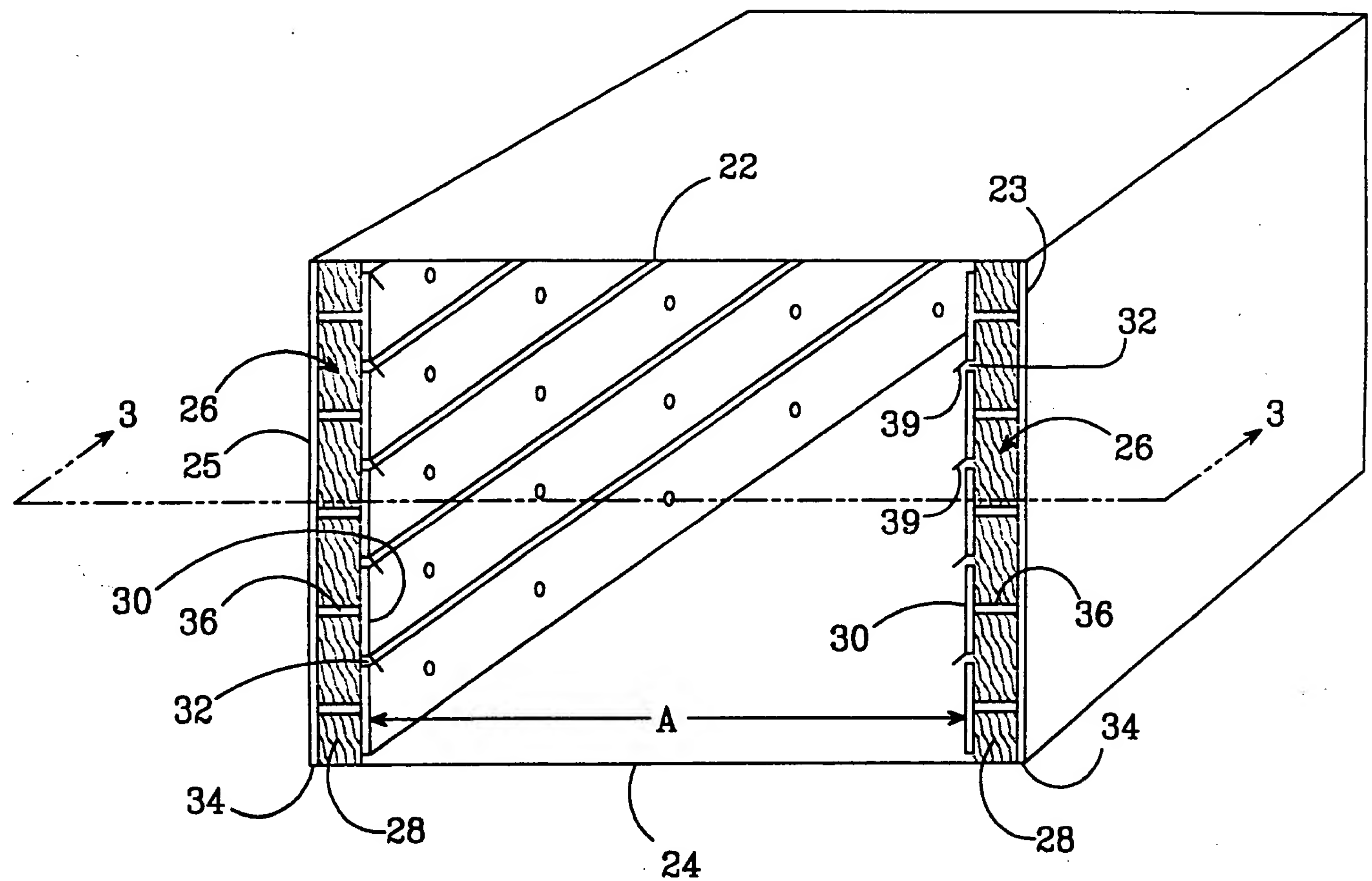


FIG.2

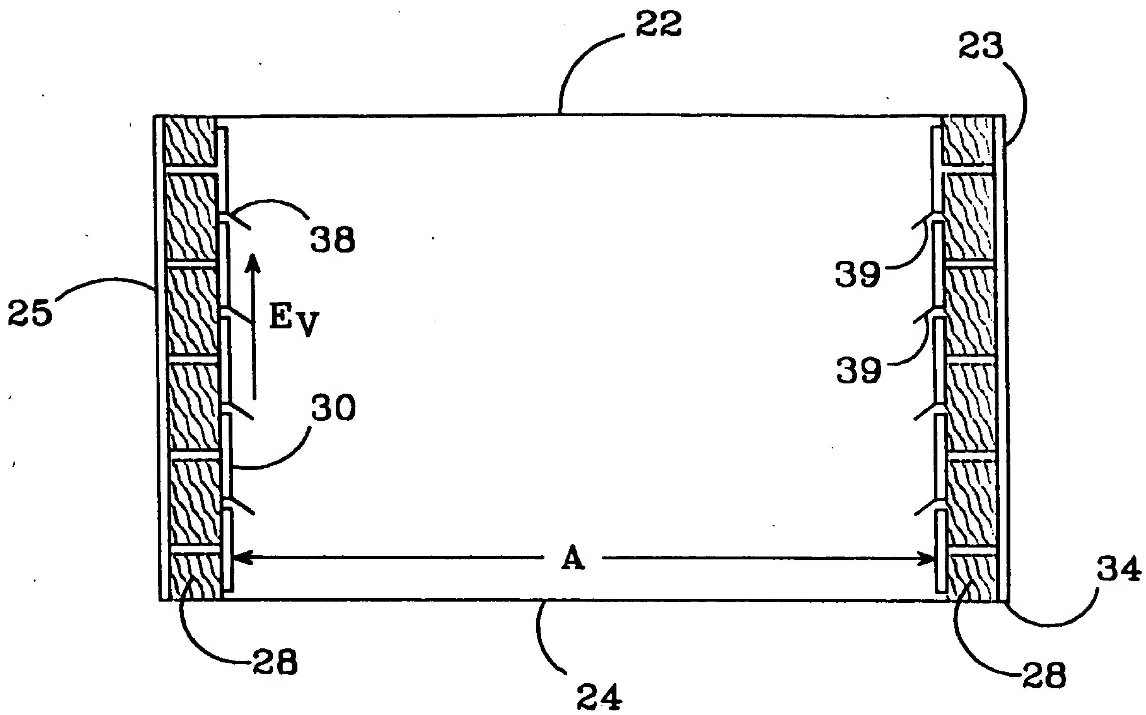
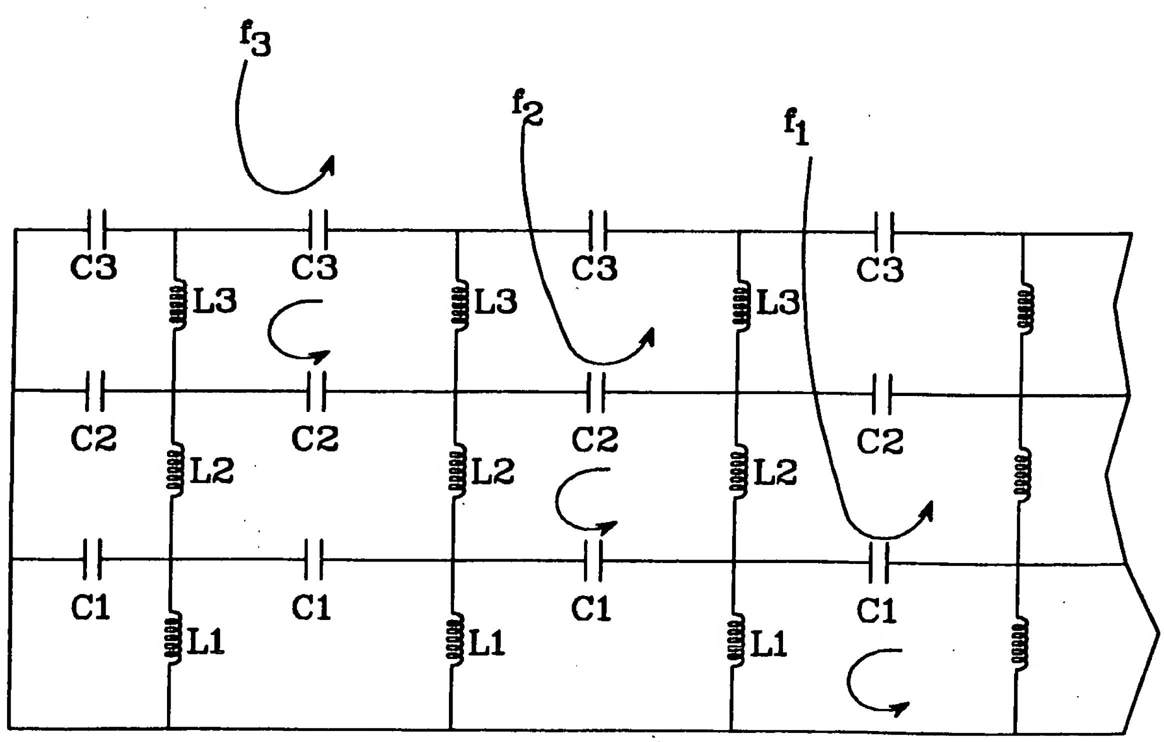

22
23
38
39
25
E_V
39
30
A
34
28
24
28

FIG.3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f_2
f_1
C3
L3
C3
L3
C3
L3
C3
C2
L2
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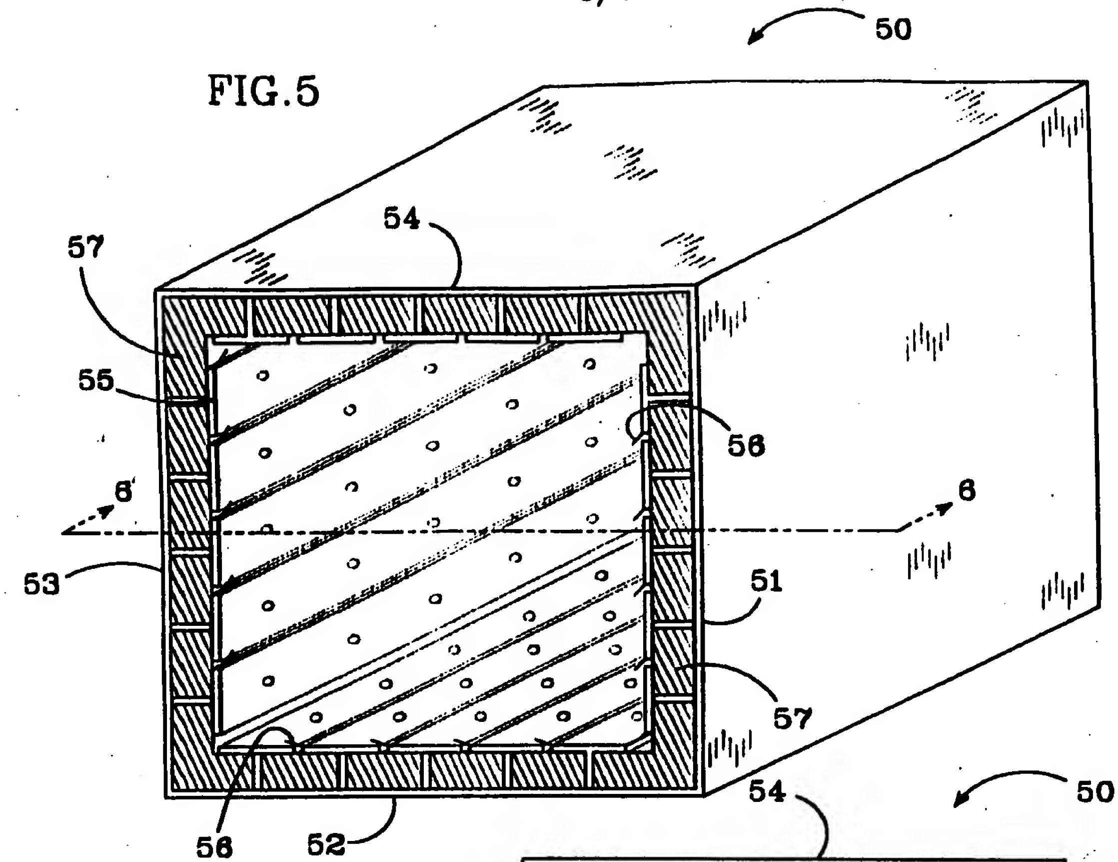
C1

FIG.9

FIG.5



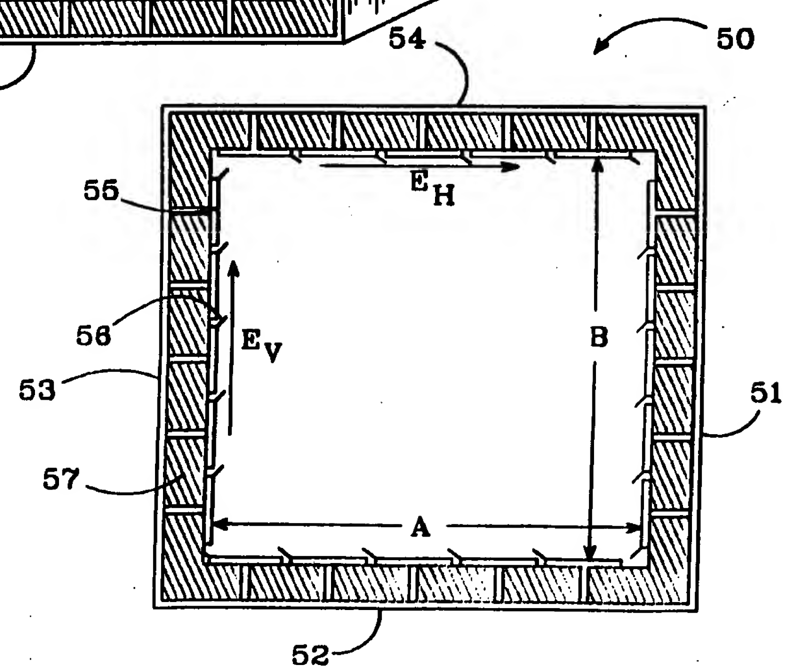


FIG.6

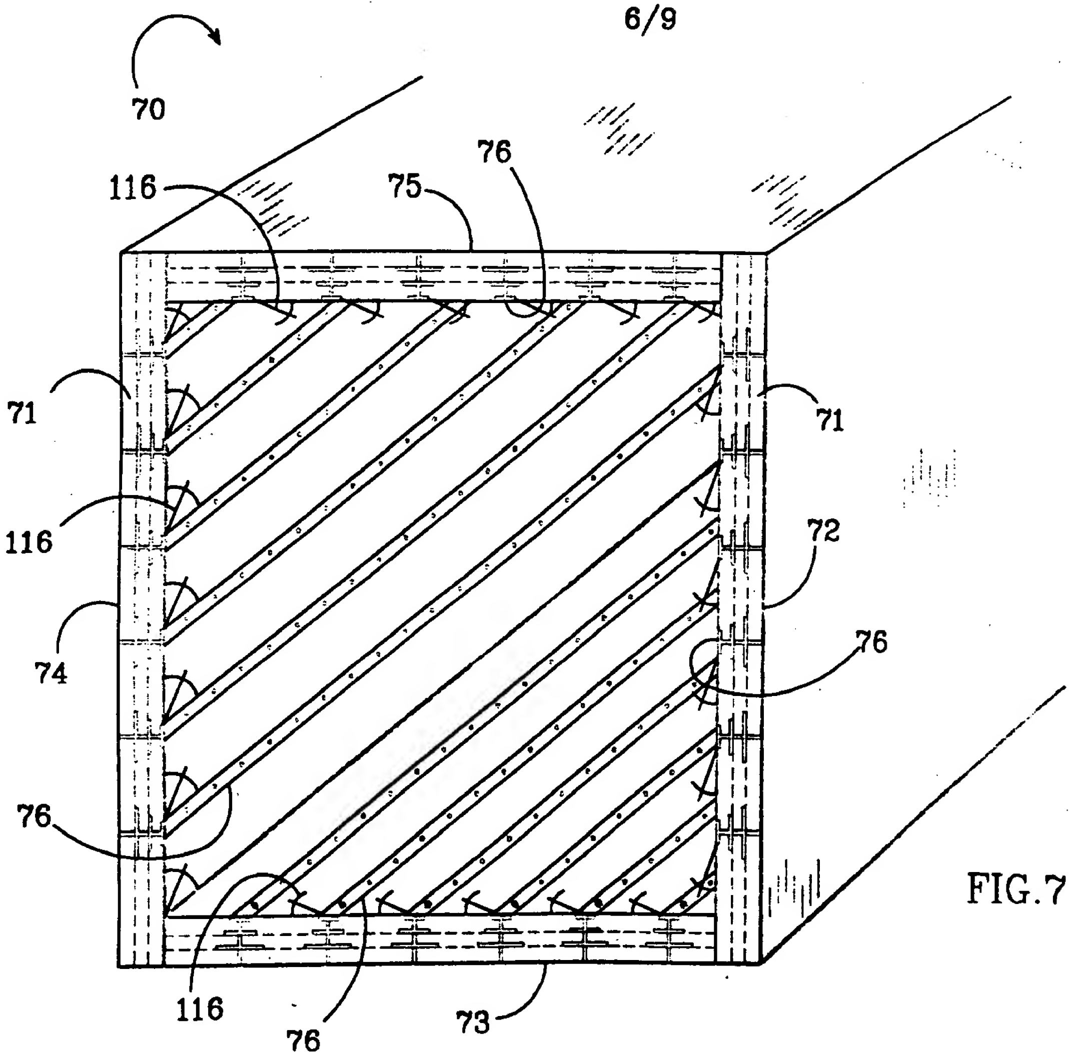


FIG.7

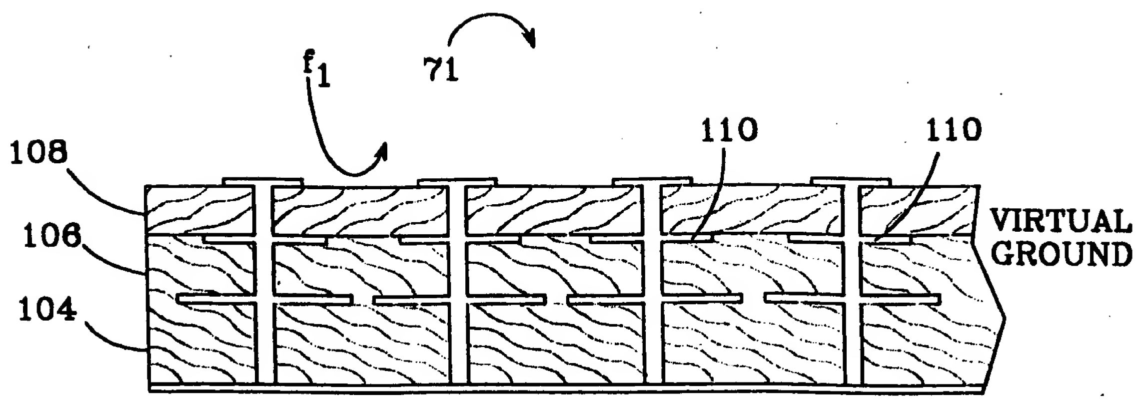


FIG.10a

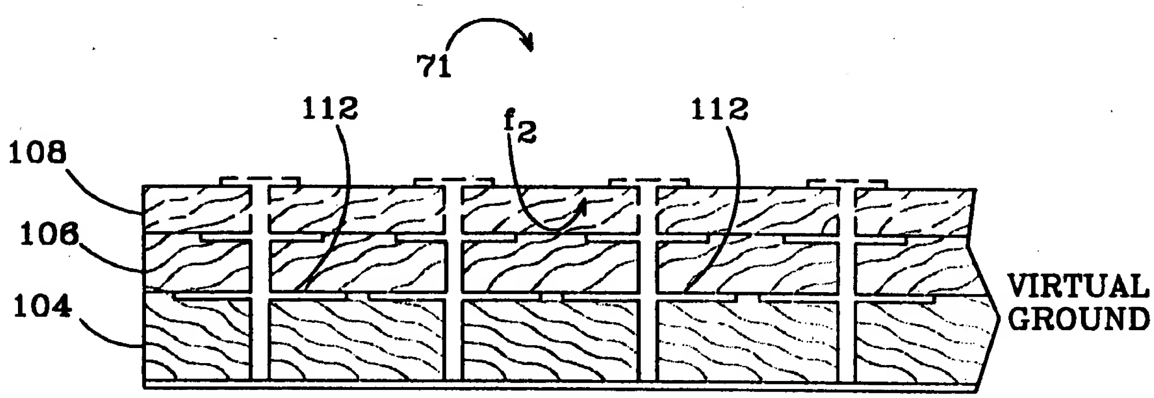


FIG.10b

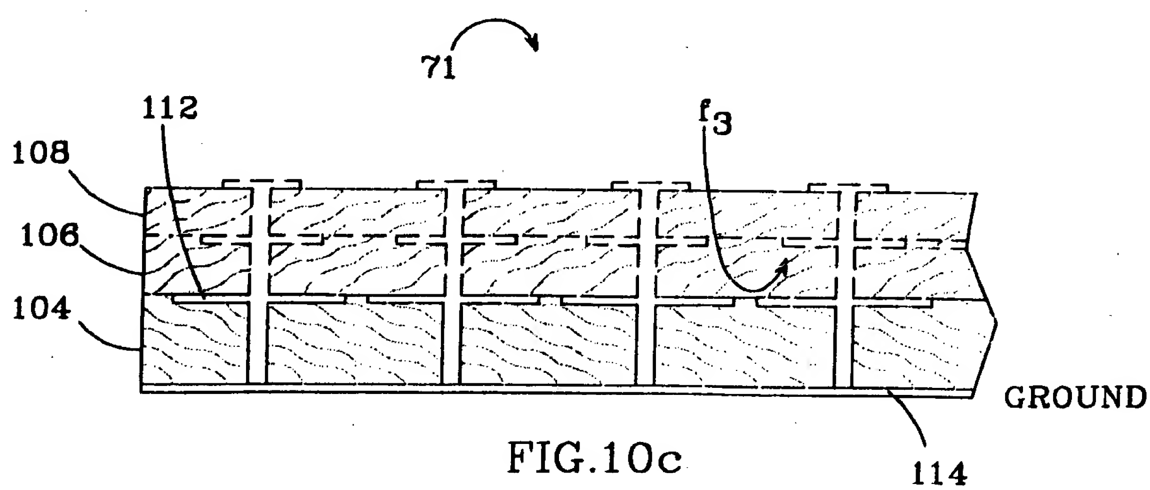


FIG.10c

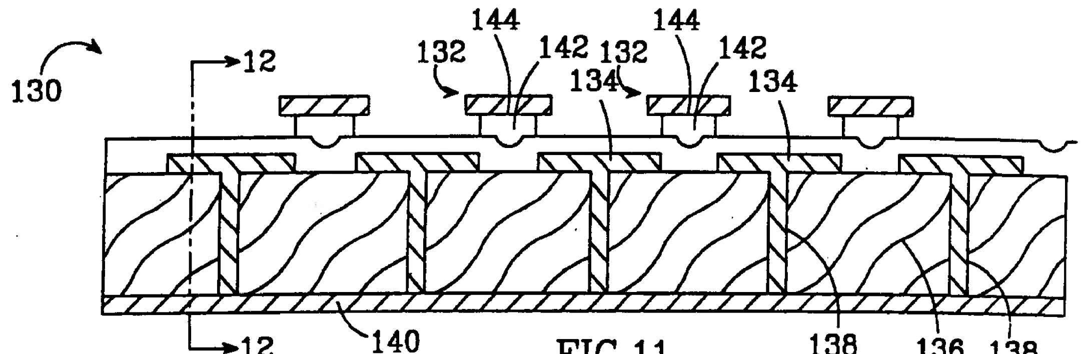


FIG.11

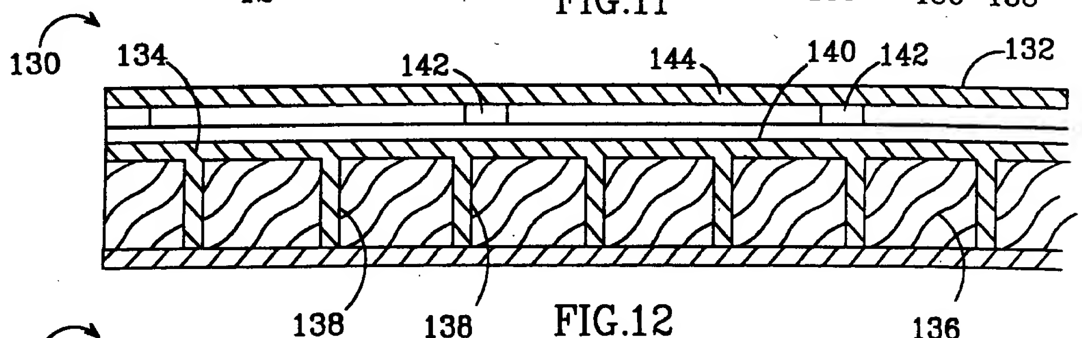


FIG.12

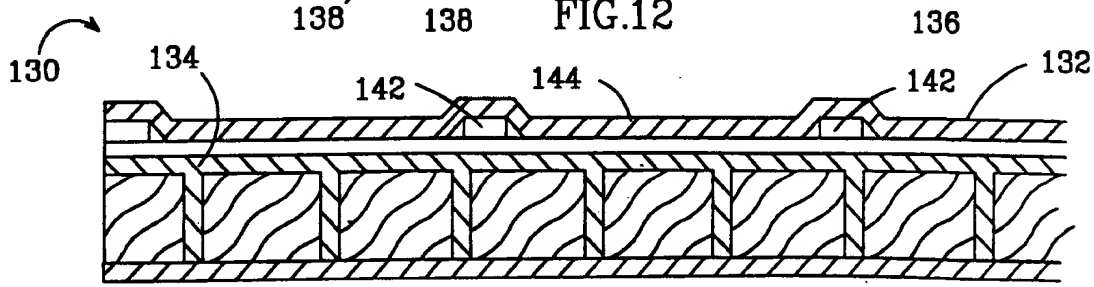


FIG.13

A-1

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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Address: COMMISSIONER FOR PATENTS
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/675,696	09/29/2000	John A. Higgins	00SC033US7	1493

7590 07/14/2003

Jaye G Heybl
Koppel & Jacobs
Suite 107
555 St Charles Drive
Thousand Oaks, CA 91360

EXAMINER	
TAKAOKA, DEAN O	
ART UNIT	PAPER NUMBER
2817	

DATE MAILED: 07/14/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

RECEIVED
JUL 17 2003
KOPPEL, JACOBS, PATRICK & HEYBL

CALENDAR ENTRY
ACTION Respond to Final OA 2 MOS
CALENDARED FOR 9/14/03

CALENDAR ENTRY
ACTION Respond to Final OA 3 MOS
CALENDARED FOR 10/14/03

PTO-90C (Rev. 07-01)

Office Action Summary	Application No.	Applicant(s)	
	09/675,696	HIGGINS, JOHN A.	
	Examiner	Art Unit	
	Dean O Takaoka	2817	

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-52 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1,31,32 and 48-52 is/are rejected.

7)☒ Claim(s) 2-30 and 33-47 is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☒ The proposed drawing correction filed on 08 May 2003 is: a)☒ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claim 48, 49, 51 and 52 are rejected under 35 U.S.C. 102(b) as being anticipated by Kanack (U.S. Patent No. 5,526,172).

Claims 48, 49 and 51:

Claim 48, 49 and 51 have not been amended and remain rejected for reasons of record contained in the office action dated January 7, 2003 (paper no. 4).

Claim 52:

Kanack shows a method of switching an electromagnetic beam (the method generic defined by the final product, thus the final product of Kanack inherently made by a method) comprising: transmitting the beam through a waveguide; and switching the walls of the waveguide between high surface impedance and low surface impedance states (tunable walls – Fig. 25a; where the closed state of the switch would inherently be a "high" impedance state and the open state would be a "low" impedance state) controls the propagation of the beam (e.g. inherent on or off, blocked or unblocked – col. 20, line 39 to col. 21, line 13) at different operating frequencies and polarizations (polarization inherent where the rectangular waveguide inherently has a plurality of polarizations, e.g. vertical and horizontal orthogonal polarizations; where tuning or

adjusting is taught, col. 20 line 66 to col. 21, line 13; where the input signal is time varying col. 4, lines 62 to col. 5, line 2 and col. 5, line 64 to col. 6, line 8).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1, 31 and 32 are rejected under 35 U.S.C. 103(a) as being unpatentable over Stafford in view of Kanack.

<u>Claim 1:</u>

Stafford (Figs. 1 – 5) shows a shutter switch for an electromagnetic wave beam (abstract, spec all where Stafford discloses parallel rays of radiation, radiation inherently electromagnetic, further where the preferred embodiment is used in a magnetooptic modulator – col. 1, line 61) comprising a plurality of waveguides (92 – Fig. 3) adapted to receive at least part of an electromagnetic beam, the waveguide being adjacent to one another (adjacent optic fibers 92 shown in Fig. 3) with their longitudinal axes aligned with the propagation of the beam; the waveguides switchable to either transmit or block transmission of the respective portion of the beam (col. 4, lines 33 – 53 where switches 93, block radiation of the optical fiber 92 or are selectively opened to allow spectrum analysis) but does not show the waveguide having sidewalls with alterable impedance properties, the waveguide switchable to alter the impedance properties of its sidewalls.

Kanack (best shown in Fig. 25a with respect to Fig. 18) shows a similar shutter switch for an electromagnetic wave beam (where Kanack shows a spatial light modulator or SLM) with the waveguide having sidewalls with alterable impedance properties, the waveguide switchable to alter the impedance properties of its sidewalls (col. 20, line 65 to col. 21, line 13).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified the shutter switch disclosed by Stafford with the adjustable waveguide sidewalls disclosed by Kanack. Such a modification would have realized the advantageous benefit of providing impedance adjustability and performance with other topologies over a wide or nearly infinite ranges (col. 23, lines 5-7; Kanack); further in that both Stafford and Kanack show spatial light modulators or SLM's which would further suggest a mere substitution of well-known art-recognized equivalent devices thus suggesting the obviousness of the modification.

Claim 31:

A millimeter beam transmission system (obvious in that a optical signal is transmitted, the optical signal obviously being defined as/in millimeter wavelengths) comprising; an electromagnetic beam transmitter (the electronic beam discussed in the reasons for rejection of claim 1 above and the transmitter obviously as source for the transmitted waves thru slit 60 shown in Fig. 3, further exemplified as the source shown in Fig. 4 and 5); an electromagnetic beam receiver (detector 100 – Fig. 3); a shutter switch (shutter switch 93) positioned in the path of the beam between the transmitter and receiver, the shutter switch comprising at least one waveguide positioned to receive

at least part of the beam, the longitudinal axis of each of the waveguides aligned with the propagation of the beam (the longitudinal axis of waveguides 92 shown aligned with the propagation of the beam – Fig. 3), each of the waveguide being switchable to either transmit or block transmission of its respective portion of the beam (the transmission or blocking of the electronic beam discussed in the reasons for rejection of claim 1 above).

Claim 32:

A radiating element for generating a electromagnetic millimeter signal and a first lens (42) positioned to collimate at least a part of the millimeter signal into a beam, and a receive receiver comprises a electromagnetic receiving element and a second lens (48) positioned to focus the beam to the receiving element, the shutter switch positioned between the first and second lenses (SLM 46 – Fig. 2 including shutter switch 93 – Fig. 3).

Claim 50 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kanack.

Claim 50 has not been amended and remains rejected for reasons of record contained in the office action dated January 7, 2003 (paper no. 4).

Response to Arguments

Applicant's arguments with respect to claims 1, 31 and 32 have been considered but are moot in view of the new ground(s) of rejection.

Applicant's arguments filed May 8, 2003 (paper no. 6) with respect to claims 48, 49 and 51 have been fully considered but they are not persuasive.

Claims 48, 49 and 51:

With respect to the prior art of Kanack (e.g. Fig. 25a), it is asserted that "*Kanack does not disclose, teach or suggest a waveguide with walls switchable between high impedance and conductive states*" to which the Examiner disagrees.

With respect to the office action of record contained in the office action dated January 7, 2003 (paper no. 4), Fig. 25a clearly shows a waveguide 242 comprising switch 80 in which switch 80 further comprises a plurality of deflectable members 88. The functionality of switch 80 comprising deflectable members 88 is disclosed with respect to Fig. 18 in which the open state of the switch would inherently be a "high impedance" and where the closed position would be a conductive state, thus blocking or unblocking the optical path, col. 20, line 39 to col. 21 line 13, as noted in the previous office action, thus the rejections of the claims are maintained by the Examiner.

Allowable Subject Matter

Claims 2 – 30 and 33 – 47 are allowed.

The reasons of allowable subject matter remains the same discussed in the previous office action dated January 7, 2003 (paper no. 4).

Conclusion

All specification and drawing objections contained in the previous office action dated January 7, 2003 (paper no. 4) are withdrawn in view of Applicant's amendment dated May 8, 2003 (paper no. 6).

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL.** See MPEP

§ 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

dot
July 7, 2003

Robert Pascal
Supervisory Patent Examiner

EV230093284US

Serial No. 09/675,696 Docket No. 00SC033US7

Client. ROCKWELL

Applicant HIGGINS, JOHN A.

Title : SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS AND METHOD FOR SWITCHING

On 5/08/03 , we mailed:

1. AMENDMENT TRANSMITTAL and duplicate.
2. AMENDMENT + DRAWINGS
3. PETITION FOR A ONE MONTH EXTENSION

Due 5/08/03. The PTO received the above on the date stamped on this card.

Serial No. 09/675,696 Docket No. 00SC033US7

Client. ROCKWELL

Applicant HIGGINS, JOHN A.

Title : SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS AND METHOD FOR SWITCHING

On 5/08/03 , we mailed:

1. AMENDMENT TRANSMITTAL and duplicate.
2. AMENDMENT + DRAWINGS
3. PETITION FOR A ONE MONTH EXTENSION

OIPE
MAY 08 2003
JC37
PATENT & TRADEMARK OFFICE

Due 5/08/03. The PTO received the above on the date stamped on this card.

Docket No. 00SC033US7 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: JOHN A. HIGGINS Examiner: Takadta

Serial No. 09/675,696 Art Unit: 1493

Filing Date: September 29, 2000

For: SHUTTER SWITCH FOR MILIMETER WAVE BEAMS AND METHOD FOR SWITCHING

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT TRANSMITTAL

Sir:

Transmitted herewith is an Amendment for this application and a Petition for a One Month Extension. Applicant is a large entity.

Fee for Claims

	Claims Remaining After Amendment	Highest No. Previously Paid For	Present Extra	Rate	Addit. Fee
TOTAL	52	52	0	18.00	0.00
INDEP.	6	3	3	84.00	252.00

Please charge Deposit Account No. 17-1580 the amount of **$252.00** reflecting the three additional independent claims. If any additional fee is required, charge Account No. 17-1580. A duplicate of this transmittal is attached.

Respectfully submitted,

May 8, 2003

Jaye G. Heybl
Registration No.42,661
Attorney for Applicant

KOPPEL, JACOBS, PATRICK & HEYBL
555 St. Charles Drive, Suite 107
Thousand Oaks, California, 91360
Telephone: (805) 373-0060

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service via Express Mail No. EV230093284US in an envelope addressed to Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on

5/08/03 Marianne Middleton
Date Marianne Middleton

PATENT
Docket No. 00SC070US7

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: John A. Higgins
Serial No.: 09/675,696 Examiner: Dean O. Takaoka
Filed: September 29, 2000 Art Unit: 1493
Title: SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS AND METHOD FOR SWITCHING

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT

Sir:

In response to the Office Action dated January 8, 2003, kindly amend the above application as follows:

Drawings

Attached are redlined FIGs. 2, 3, 5, 6, 7. 10c and 11-15.

Specification

Replace the corresponding paragraph in the original application with the following paragraph:

Page 11, lines 20-32:

FIGs. 2 and 3 show one embodiment of the waveguide 12 used to construct the shutter switch 10. Its top and bottom walls 22 and 24 are conductive, and the inside of its sidewalls 23, 25 have high impedance structure 26. The structure 26 includes a sheet of dielectric material 28 with conductive strips 30 of uniform width on one side, the conductive strips 30 having a uniform gap 32 between

included on the side of the dielectric material 28 opposite the conductive strips 30. Vias 36 of conductive material are provided between the conductive strips 30 and the conductive layer 34, through the dielectric material 28. The conductive strips 32 are oriented longitudinally down the waveguide 12.

Page 12, line 20 to page 13, line 2:

Holes are created through the dielectric material 28 at uniform intervals, the holes continuing through the dielectric material 28 to the conductive strips 30 on the other side. The holes can be created by various methods, such as conventional wet or dry etching. They are then filled or covered with the conductive material and the uncovered side of the dielectric material is covered with a conductive material, both accomplished using sputtered vaporization plating. The holes do not need to be completely filled but the walls of the holes must be covered with the conductive material. The covered or filled holes provide conductive vias 36 between the conductive layer 34 and the conductive strips 30. The dimensions of the dielectric material 28, the conductive strips 34 and the vias 39 depend on the particular design frequency for the waveguide 12.

Page 13, lines 3-21:

With the high impedance structure 26 on the waveguide's sidewalls such that the conductive strips run parallel to the waveguides longitudinal axis, the structure will present a high impedance to the E field component of a vertically polarized signal at the design frequency. As shown in FIG. 4, the gap 32 presents a capacitance 38 to the E field component that is transverse to the conductive

strips. The capacitance 38 is primarily dependant upon the width of the gap 32 between the strips 30 but is also impacted by the dielectric constant of the dielectric material 28. The structure 26 also presents an inductance 40 to a transverse E field, the inductance 40 being dependant primarily on the thickness of the dielectric material 28 and the diameter of the vias 36. At resonant frequency, the structure presents parallel resonant L-C circuits 42 to the vertically polarized signal and, as a result, a high impedance to a transverse E field. The E field maintains uniform power density across the waveguide, during transmission through the waveguide.

Page 13, line 28, to page 14, line 13:

The wall structure 26 also has a shorting switch 39 at each of the gaps 32 that short their respective gap when closed, the details of the switches described below and shown in FIGs. 11-14. When the switches 39 are open, the structure functions as described above, presenting a high impedance to a transverse E field. The gaps 32 form the capacitive part of the resonant L-C circuits and by closing the switches 39, the gaps 32 and their capacitance are shorted. The conductive strips 30 and closed switches 39 change the characteristics of the structure 26 such that it presents as continuous conductive sheet. The waveguide 12 now has conductive sidewalls along with the conductive top and bottom walls. Because the waveguides physical dimension "A" in FIG. 2 is less than the critical dimension required for the frequency, signal transmission is cut-off and blocked. In the preferred embodiment, the switches 39 in all the waveguides of the shutter switch 10 are closed simultaneously, causing all the waveguides to block transmission of the signal.

Page 16, lines 10-18:

The structure 57 is manufactured using similar materials and processes described above for the embodiment shown in FIGs. 2 and 3, and the manufacturing of the shorting switches is described below. By selectively closing the switches on opposing walls of the waveguide 50, the horizontal portion, vertical portion, or both, can be cut-off. A shutter switch constructed of these waveguides can selectively block portions of a cross-polarized beam, or the entire beam.

Page 16, line 12 to page 17, line 4:

FIG. 7 shows another embodiment of the waveguide 70 used to construct the shutter switch 10. The waveguide has a three-layered high impedance 71 structure its walls 72-75. In alternative embodiment the structure 71 can be on the waveguides sidewalls 72, 74 with its top and bottom walls 73, 75 being conductive, or the structure can be on the waveguides top and bottom walls 73, 75 with its sidewalls 72, 74 being conductive. The structure 71 can have different numbers of layers, depending on the number of frequencies to be transmitted by the waveguide. The structure 71 shown has three layers and presents a high impedance to transverse E fields at three different resonant frequencies.

Page 20, line 19 to page 21, line 5:

FIGs 10a-10c illustrate how the three signals interact with layers of the new structure 71. An important

characteristic of the structure's layers 104, 106, and 108 is that each appears transparent to E fields at frequencies below its design frequency, and the strips appear as a conductive surface to E fields at frequencies above its design frequency. For the highest frequency signal f1, the top layer 108 presents as high impedance resonant L-C circuits to the signal's transverse E field. The strips 110 on second layer 106 appear as a conductive layer and become a "virtual ground" for the top layer 108. Signal f2 is lower in frequency than f1 and, as a result, the first layer 104 is transparent to f2's E field, while the second layer 106 appears as high impedance resonant L-C circuits. The strips 112 on the third layer appear as a conductive layer, becoming the second layer's virtual ground. Similarly, at f3 the top and second layers 108 and 106 are transparent, but the third layer 104 appears as high impedance resonant L-C circuits, with the conductive layer 114 being ground for the third layer 104.

Page 21, line 29, to page 22, line 12:

Shorting switches 116 are shown as symbols on the top layer of the structure 71 on the walls 72-75, and the details of the switches are described below and shown in FIGs. 11-14. If the switches are closed on the top layer on all four of the waveguide's walls, the waveguide 70 is changed from transparent to opaque at all three frequencies. For instance, at the lowest frequency, when the first two layers of the structure appear transparent and closing the switches on the top layer shorts the gap capacitance and causes the signal to see only the conductive surface presented by the top layer's conductive

strips and closed switches. The same is true for the next higher frequencies. Closing the switches causes them to see only a conductive surface, cutting off transmission.

Page 22, line 23, to page 23, line 9:

If switches 116 are included at each of the layers (not shown) then different frequencies at different polarizations can be selectively blocked. For example, f3 could be blocked in both polarizations if the switches 116 are closed on the bottom layer 82 (shown in FIG. 8) on all four walls. Only for f3 will the all the layers appear as conductive layers, cutting off transmission at f3. If the shorting switches 116 are closed on the bottom layer 82 on the top and bottom walls 73, 75 only, transmission of the horizontally polarized signal at f3 is blocked, while still transmitting the vertically polarized signals at f3. If the switches 116 are closed on the bottom layer 82 on the sidewalls, transmission of the vertically polarized signal at f3 is blocked. By selectively closing the switches 116 at the other layers 84, 86, the different frequencies in different polarizations can be blocked.

Page 23, line 25, to page 24, line 7:

FIGs. 11, 12 and 13, show one embodiment of the MEMS shorting switches 132 constructed in accordance with the present invention to short the conductive strips 134 in the high impedance structure 130. The switches 132 are fabricated using generally known micro fabrication techniques, such as masking, etching, deposition, and lift-

off. FIG. 11 is a sectional view of the high impedance structure 130 taken transverse to the conductive strips 134. FIG. 12 is a sectional view taken long sectional lines one of the shorting switches 132. Both show high impedance structure's dielectric material 136, vias 138 and conductive layer 140.

Page 24, lines 8-17:

The switches 132 are manufactured by depositing semiconductor layer 140 over the conductive strips 134 and over the exposed surface of the dielectric material 136, the preferred semiconductor material being Si_3N_4. Stand-off isolators 142 are deposited at intervals down the gap between the conductive strips 134 and are preferably formed of an insulator material such as silicon dioxide. A respective strip of metallic material 144 is mounted over each of the gaps by affixing it on the top of the stand-offs 142 along one of the gaps.

Page 24, lines 18-28:

In operation, each metallic strip 144 has either 0 volts or voltage potential applied, with the preferred potential being 50 volts. With 0 volts applied, the strips 134 remain suspended above their respective gap between the stand off isolators 142 as shown in FIG. 12. The switches are in the "Off" state and the structure 130 presents as a high impedance to the design frequency E field transverse to the conductive strips 134. The gaps between the strips 134 presents a capacitance and the vias 138 present an inductance, with the structure presenting as a series of

resonant L-C circuits to the transverse E field.

Page 24, line 29 to page 25, line 10:

Referring now to FIG. 13, to close the switch 132 and short the gap between conductive strips 134 a 50 volt potential is applied to the metallic strips 144. This causes an electrostatic tension between the metallic strips 144 and the respective conductive strips 134 below, pulling the switch strip down such that it makes capacitive contact with the strip 134 on each side of the gap. This provides a conductive bridge across the gap, shorting the gap. With all the metallic strips 144 pulled to the strips 134 below, the high impedance structure appears as a conductive surface to the signal's E field. This switching network consumes very little and has a very fast closure time on the order of 30 μs.

Page 25, lines 11-19:

FIG 14 shows a high impedance structure 150 with a second embodiment of the shorting switches 152 that utilize varactor diode technology to short the gaps. The varactor diode is an ordinary junction diode that relies on its voltage dependent capacitance. Each varactor switch includes a N+ (highly conducting) layer 154 grown or deposited in the each gap between the conductive strips 156. An N- (moderately conducting) layer 158 is grown on top of top of a portion of the N+ layer 154.

Page 25, lines 20-30:

In fabricating the switches 152, the N+ and N- layers 154 and 158 are etched into mesas that will provide a strip of varactor material along the length of the gaps between the conductive strips 156. The switching of the varactor is

controlled by a second conductive strip 160 sitting on an insulator layer 162 that is sandwiched between the second strip 160 and each conductive strip 156. The insulator layer 162 provides a capacitive coupling to conductive strip 156 and the ground plane. Voltage applied to the second strip 160 controls the capacitance of the varactor layer and thus the shorting of the gap.

Page 26, lines 9-27:

FIG. 15 shows millimeter beam transmission system 170 used in various high frequency applications such as munitions guidance systems (e.g. seeker radar). A transmitter 172 generates a millimeter signal 174 that spreads as it moves from the transmitter. Most of the signal is directed toward a lens 176 that collimates the signal into a beam 177 with little diffraction. The collimated beam travels to a second lens 158 that focuses the beam to a receiver 180. The shutter switch 182 is positioned between a millimeter wave transmitter 172 and receiver 180 such that it intercepts the transmission beam 177. When the shorting switches on the shutter switch's waveguides are open, the shutter switch 182 is transparent to the beam and the signal passes from the transmitter 172 to the receiver 180. When the shorting switches are closed, transmission of the signal through each of the waveguides is cut-off, making the shutter switch 182 opaque to the beam 177 and blocking transmission from the transmitter to the receiver.

Page 26, line 28, or page 27, line 2:

As described above, when the waveguides in the shutter switch 182 have the high impedance structure on the

sidewalls and the top and bottom walls, the beam can have horizontal and vertical polarization and the shutter switch 182 can block one or both of the polarizations. When the high impedance structure has multiple layers, the shutter switch can be transparent or block signals at multiple frequencies and at one or both polarizations.

Claims

Replace the corresponding claims in the original application with the following amended claims:

1. A shutter switch for an electromagnetic wave beam, comprising:

a plurality of waveguides adapted to receive at least part of an electromagnetic beam, said waveguides having sidewalls with alterable impedance properties, said waveguides being adjacent to one another with their longitudinal axes aligned with the propagation of said beam each of said waveguides switchable to alter the impedance properties of its sidewalls to either transmit or block transmission of its respective portion of said beam.

2. A shutter switch for an electromagnetic wave beam, comprising:

a plurality of waveguides adapted to receive at least part of an electromagnetic beam, said waveguides being adjacent to one another with their longitudinal axes aligned with the propagation of said beam, said waveguides switchable to either transmit or block transmission of their respective portions of said beam, wherein each of said waveguides comprises:

four wall inside surfaces comprising two opposing sidewalls and a top and bottom wall;

respective high impedance wall structures on at least two opposing walls, said wall structures presenting a high surface impedance to E fields transverse to the waveguide axis and tangential to the said opposing wall structure, and a low impedance to E fields parallel to the waveguide axis; and

shorting arrangements on each said wall structures to short circuit their high impedances;

each of said waveguides having internal dimensions to cut-off the transmission of its respective portion of said beam when its high impedance wall structure is short circuited to a low impedance state.

3. The shutter switch of claim 2, wherein each said high impedance wall structure comprises:

a sheet of dielectric material having two sides;

a conductive layer on one outer side of said dielectric material;

a plurality of mutually spaced conductive strips on the other inner side of said dielectric material, said strips having gaps between adjacent said strips and being aligned parallel to the guide longitudinal axis; and

a plurality of conductive vias extending through said dielectric material between said conductive layer and said conductive strips.

5. The shutter switch of claim 3, wherein adjacent pairs of said strips present a capacitance and said dielectric sheet presents an inductance to an electromagnetic beam with an E field transverse and tangential to said conductive strips.

6. The shutter switch of claim 5, wherein said conductive strips and dielectric material present a series connection of parallel L-C circuits, resonant at an operating frequency, to an electromagnetic beam with an E field transverse and tangential to said conductive strips.

8. The shutter switch of claim 3, wherein said high impedance structure are provided on said waveguide's sidewalls and present a high impedance to the E field component of a vertically polarized guided beam.

9. The shutter switch of claim 3, wherein said high impedance structure are provided on said waveguide's top and bottom walls and present a high impedance to the E field component of a horizontally polarized guided beam.

10. The shutter switch of claim 3, wherein said high impedance structure are provided on said waveguide's sidewalls and top and bottom walls and present a high impedance to the E field component of both vertically and horizontally polarized beams.

11. The shutter switch of claim 3, wherein said shorting arrangements change said high surface impedance structure to a conductive surface by shorting said gaps between said conductive strips.

12. The shutter switch of claim 11, wherein said shorting arrangements comprise micro electromechanical systems (MEMS) switches.

13. The shutter switch of claim 12, wherein each of said

MEMS shorting arrangements comprises a shorting strip suspended over said gap between a respective pair of said conductive strips, said gap being shorted by applying a voltage potential to adjacent electrodes creating an electrostatic tension that pulls said shorting strip down to said conductive strips to form a conductive bridge across said gap between said conductive strips.

14. The shutter switch of claim 11, wherein said shorting comprise varactor diode in each of said gaps.

15. The shutter switch of claim 14, wherein each of said varactor diode places a variable capacitance across its respective said gap such that a voltage may be applied to detune the parallel L-C circuits away from said operating frequency thus rendering the high surface impedance to a low impedance state and causing a cut-off state for said guide at said operating frequency.

16. The shutter switch of claim 2, wherein said high impedance wall structure comprises:

a plurality of stacked high impedance layers, each presenting a high impedance surface to the E field component of a different respective electromagnetic beam operating frequency and being transparent to the E fields of lower operating frequency signals, and presenting a low impedance surface to the E field of higher operating frequency signals; and

the bottommost said layer presenting a high impedance surface to the E field of the lowest frequency of said operating signals, and each succeeding layer presenting a high impedance surface to the E field of successively higher operating frequencies.

18. The shutter switch of claim 16, wherein corresponding conductive strips of said high impedance layers are aligned along the guide longitudinal axis and said high impedance layers further comprise conductive vias through said dielectric substrates between said aligned conductive strips and said conductive layer.

20. The shutter switch of claim 16, wherein each of said high impedance layers presents a series connection of resonant parallel L-C circuits to the E field of its respective operating frequency.

22. The shutter switch of claim 16, wherein said high surface impedance wall structures are on said waveguide's sidewalls and present a high impedance to the E field component of said different frequency beams having vertical polarization.

23. The shutter switch of claim 16, wherein said high impedance wall structures are on said waveguide's top and bottom walls and present a high impedance to the E field component of said different frequency beams having horizontal polarization.

24. The shutter switch of claim 16, wherein said high impedance structures are on said waveguide's sidewalls and top and bottom walls and present a high impedance to the E field component of said different frequency beams having both vertical and horizontal polarization.

25. The shutter switch of claim 17, further comprising shorting arrangements on each of said plurality of layers

to change said high surface impedances to a conductive surfaces by shorting said gaps between said conductive strips.

26. The shutter switch of claim 25, wherein said shorting arrangements comprises micro electromechanical systems (MEMS) switches.

27. The shutter switch of claim 26, wherein each of said MEMS switches comprises a shorting strip suspended over said gap between a respective pair of said conductive strips, said switch being closed by applying a voltage potential to adjacent electrodes creating an electrostatic tension that pulls said shorting strip down to said conductive strips to form a conductive bridge across said gap between said conductive strips.

28. The shutter switch of claim 25, wherein said shorting switches comprise varactor diode in each of said gaps.

29. The shutter switch of claim 28, wherein each of said varactor diode places a variable capacitance across its respective said gap such that a voltage may be applied to detune the parallel L-C circuits away from said operating frequency thus rendering said high surface impedance to a low impedance state.

30. The shutter switch of claim 28, wherein said shorting arrangements are closed on selective layers of said high impedance structures to block transmission one or both polarities of said beam at one or all of said different frequency signals.

31. A millimeter beam transmission system, comprising;

an electromagnetic beam transmitter;

an electromagnetic beam receiver;

a shutter switch positioned in the path of said beam between said transmitter and receiver, said shutter switch comprising at least one waveguide positioned to receive at least part of said beam, the longitudinal axis of each of said waveguides aligned with the propagation of said beam, each of said waveguide having sidewalls with alterable impedance properties to either transmit or block transmission of its respective portion of said beam.

33. A millimeter beam transmission system, comprising;

an electromagnetic beam transmitter;

an electromagnetic beam receiver;

a shutter switch positioned in the path of said beam between said transmitter and receiver, said shutter switch comprising at least one waveguide positioned to receive at least part of said beam, the longitudinal axis of each if said waveguides aligned with the propagation of said beam, each of said waveguide being switchable to either transmit or block transmission of its respective portion of said beam, wherein each said waveguide comprises:

four wall inner surfaces comprising two opposing sidewalls and a top and bottom wall;

a high impedance wall structure on at least two opposing walls of said waveguide, said wall structure presenting a high surface impedance to E fields transverse to the waveguide axis and tangential to the wall structure, and a low impedance to E fields parallel to the waveguide axis; and

shorting arrangements on each said high impedance structure to change the high surface impedance of said

structure to a low impedance surface.

34. The system of claim 33, wherein each said waveguide has inner dimensions such that the transmission of said electromagnetic beam is cut-off when said waveguide sidewalls and top and bottom walls are low impedance surfaces.

35. The system of claim 33, wherein each said high impedance wall structure comprises:

a sheet of dielectric material having two sides;

a conductive layer on one outer side of said dielectric material;

a plurality of mutually spaced parallel conductive strips on the other inner side of said dielectric material; and

a plurality of conductive vias extending through said dielectric material between said conductive layer and said conductive strips.

37. The system of claim 36, wherein said conductive strips, vias and dielectric material present a series connection of parallel L-C circuits to an electromagnetic wave with an E field transverse and tangential to said conductive strips.

38. The system of claim 36, wherein said shorting arrangements change said high surface impedance structure to a low impedance surface by shorting said gaps between said conductive strips.

39. The system of claim 33, wherein said high impedance wall structure comprises:

a plurality of stacked high surface impedance layers,

each presenting a high surface impedance to the E field component of a different respective electromagnetic beam operating frequency and being transparent to the E fields of lower frequency signals, and presenting a low impedance surface to the E field of higher frequency signals; and

the bottommost said layer presenting a high surface impedance to the E field of the lowest frequency of said signals, and each succeeding layer presenting a high surface impedance to the E field of successively higher frequencies.

40. The system of claim 39, wherein each said layer presents a series connection of resonant parallel L-C circuits to the E field of its respective signal operating frequency.

42. The system of claim 39, wherein corresponding conductive strips of said layers are aligned along longitudinal axis of said guide and said high impedance structure further comprises conductive vias through said dielectric substrates between said aligned conductive strips and said conductive layer.

43. The system of claim 39, wherein said shorting arrangements change said high surface impedance structure to a low impedance surface by shorting said gaps between said conductive strips.

44. The system of claim 33, wherein said high impedance structure are provided on said waveguide's sidewalls and present a high impedance to a transverse and tangential E field component of vertically polarized beams at one or more operating frequencies.

45. The system of claim 33, wherein said high impedance structure are provided on said waveguide's top and bottom walls such that said high impedance structure presents a high surface impedance to an E field component of a horizontally polarized beams at one or more operating frequencies.

46. The system of claim 33, wherein said high impedance structures are provide on said waveguide's sidewalls and top and bottom walls and present a high impedance to the E transverse and tangential field components of a vertically and horizontally polarized beams at one or more operating frequencies.

47. The system of claim 46, wherein said shorting arrangements are closed on selective layers of said high impedance structures to block transmission one or both polarities of said beam at one or all of said different operating frequency signals.

52. A method of switching an electromagnetic beam, comprising:

transmitting said beam through one or more waveguides; and

switching the walls of said waveguides between high surface impedance and low surface impedance states to control the propagation of said beam, wherein said electromagnetic beam is horizontally and/or vertically polarized, and has different operating frequencies, the switching of the walls between high surface impedance and low surface impedance states controls propagation of said beam at different operating frequencies and polarizations.

REMARKS

Specification

The examiner objected to the specification regarding inconsistencies surrounding reference numbers 34 and 38, and the specification has been amended to correct the inconsistencies.

Numerous clerical errors were also discovered in the specification and have been corrected herein.

Drawings

The examiner objected to the drawings because reference numeral 23 and 25 in FIGs. 2 and 3 did not appear to be disclosed in the specification. The specification was amended in the paragraph on page 11, lines 20-32, to disclose these reference numerals without adding new matter.

The examiner also objected to FIG. 7 because reference numeral 76 was not disclosed in the specification. A red-lined FIG. 7 is attached with reference numeral 76 deleted and new formal drawings will be submitted upon approval of the examiner.

The examiner also objected to FIGs. 5 and 7 because of missing reference numerals and red-lined FIGs. 5 and 7 are attached with changes to include the reference numerals and to correct other clerical errors. New formal drawings will be submitted upon approval of the examiner.

Applicant also discovered clerical errors in FIGs. 2, 3, 6, 10c and 11-15. These figures are also attached with red lined amendments to correct the clerical errors and new formal drawings will be submitted upon approval of the examiner.

Claims

Objections

The examiner objected to claim 31 because of a clerical error and the claim has been amended pursuant to the examiner's suggestion.

Rejected Claims

35 U.S.C. 102(b)

Claims 1, 31 and 32

The examiner rejected claims 1, 31 and 32 under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No. 5,504,575 to Stafford. Claim 1 and 31 has been amended to overcome Stafford and applicant respectfully requests reconsideration of this rejection. Claim 32 depends from allowable claim 31 and is also allowable.

The disclosure of Stafford will be discussed, followed by a discussion of why amended claims 1 and 31 are allowable.

Stafford

Stafford relates to spectrometers, and more particularly, relates to spectrometers employing a spatial light modulator (SLM), such as a deformable mirror device (DMD). FIG. 3 and the supporting disclosure in Stafford were primarily relied upon by the examiner. FIG. 3 shows a SLM 90 employed in the SLM spectrometer 7, that is comprised of a linear array of small optical fibers 92 (arranged side-by-side) disposed to receive the dispersed spectrum into one end (inlet) and pass their respective discrete portions of the spectrum out at the other end (outlet) to a detector 100. Each optical fiber contains an optical shutter (or switch) 93 between the inlet and outlet

ends. The optical shutters or switches 93 are normally closed to block any radiation in their respective optical fiber 92 from the detector 100, and are selectively opened to analyze the spectrum incident on the array of fibers. After the optical shutters 93, the optical fibers are twisted and aligned to focus their respective output radiation onto the detector 100. An array of small liquid crystal devices (LCDs) may be positioned in a parallel set of openings in the array of fibers and may be employed as the optical shutters. The absorption wavelength(s) of the type of optical fiber employed must be outside the wavelengths of the spectra of interest.

The present invention discloses a shutter that is placed in the path of a millimeter beam and is either opaque or transparent to the beam. The shutter switch comprises a number of waveguides placed adjacent to one another to intercept the beam, a portion of the beam passing through each waveguide. The dimensions of each waveguide are such that transmission of the respective portion of the beam would be cut-off if the all of the waveguide walls were conductive. However, the waveguides have high impedance structures on at least two of their opposing interior walls that allow the beam at the design frequency to be transmitted through the waveguide with uniform density and minimal attenuation. At this design frequency the shutter switch to be essentially transparent to the beam. The high impedance structures can also be changed to a conductive surfaces such that all of the waveguides walls appear conductive and the waveguide takes on the characteristics of a metal rectangular waveguide. In this state transmission through each waveguide is cut-off and the shutter switch blocks transmission of the beam. The

shutter switch can change states from blocking to transparent in microseconds or less while consuming very little power.

An important difference between Stafford and the present invention is that waveguides in Stafford do not have impedance structures on their sidewalls. Instead, Stafford utilizes simple "optical fiber 92". To block transmission through the waveguide in Stafford, optical shutters or switches 93 are included that block the light. The present invention utilizes a much different arrangement that changes the impedance of the sidewalls in the waveguides to block or allow transmission of the beam through the waveguide.

To emphasize these differences, claim 1 has been amended such that the shutter switch comprises:

> a plurality of waveguides adapted to receive at least part of an electromagnetic beam, said waveguides <u>having sidewalls with alterable impedance properties, said waveguides</u> being adjacent to one another with their longitudinal axes aligned with the propagation of said beam <u>each of</u> said waveguides switchable <u>to alter the impedance properties of its sidewalls</u> to either transmit or block transmission of [their] <u>its</u> respective [portions] <u>portion</u> of said beam.

Stafford does not disclose, teach or suggest a switch with waveguides having alterable impedance properties of amended claim 1. Applicant believes that amended claim 1 is allowable over Stafford and the other references cited in the office action.

Claim 31 was rejected on similar grounds that claim 1

was rejected, and claim 31 was amended to include similar limitations regarding alterable impedance properties on the waveguide sidewalls. For the same reasons that claim 1 is allowable, claim 31 and its dependant claim 32 are also allowable.

Claims 48, 49 and 51

The examiner rejected claims 48, 49 and under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No. 5,526,172 to Kanack. Regarding claim 48, the examiner essentially concluded that FIG. 25a of Kanack shows a waveguide wherein the walls can be switchable between high impedance and conductive state to control the propagation of selected modes of a beam. Applicant respectfully submits that Kanack does not show a waveguide with these features and requests reconsideration of this rejection.

In discussing FIG. 25a, Kanack notes that another use of arrays disclosed in the patent are for the interior surfaces of the walls of a waveguide. In this embodiment, movement of the 88 of the switch 80 can selective "reduce (or increase) the cross-section of the waveguide, thereby altering electrical characteristics thereof. (col. 24, lines 21-31).

Kanack does not disclose, teach or suggest a waveguide with walls switchable between high impedance and conductive states. Instead, Kanack simply relies on the properties of its swiches 80 to change the cross-section of the waveguide. There is no mention of the Kanack waveguide having impedance properties.

Applicants submit that Kanack does not disclose, teach or suggest the limitations of claim 48, and that claim 48 is allowable over Kanack. Claims 49 and 51 depend from claim 48 and are also allowable.

35 U.S.C. 103(a)

The examiner rejected Claim 50 pursuant to 35 U.S.C. 103(a) as being unpatentable over Kanack. Claims 50 depends from allowable claim 48, and is also allowable for the same reasons that claim 48 is allowable.

Allowed Subject Matter

Claims 2-30, 33-47 and 52 were objected to as being dependant upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitation of the base claim and any intervening claims. Dependant claim 2 has been amended in independent form and claims 3-30 depend from claim 2. Claim 33 has been amended in independent form and claim 34-47 depend from claim 33. Claim 52 has also been amend in independent form. All of these claims are now allowable.

All of the claims are now believed to be in proper form for allowance, and a Notice of Allowance is respectfully requested.

Respectfully submitted,

Dated: May 8, 2003

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

Specification

Page 11, lines 20-32:

FIGs. 2 and 3 show one embodiment of the waveguide 12 used to construct the shutter switch 10. Its top and bottom walls 22 and 24 are conductive, and the inside of its sidewalls 23, 25 have high impedance structure 26. The structure 26 includes a sheet of dielectric material 28 with conductive strips 30 of uniform width on one side, the conductive strips 30 having a uniform gap 32 between adjacent strips 30. A layer of conductive material 34 is included on the side of the dielectric material 28 opposite the conductive strips 30. Vias 36 of conductive material are provided between the conductive strips 30 and the conductive layer 34, through the dielectric material 28. The conductive strips 32 are oriented longitudinally down the waveguide 12.

Page 12, line 20 to page 13, line 2:

Holes are created through the dielectric material 28 at uniform intervals, the holes continuing through the dielectric material 28 to the conductive strips 30 on the other side. The holes can be created by various methods, such as conventional wet or dry etching. They are then filled or covered with the conductive material and the uncovered side of the dielectric material is covered with a conductive material, both accomplished using sputtered vaporization plating. The holes do not need to be completely filled but the walls of the holes must be covered with the conductive material. The covered or filled holes provide conductive vias [39] 36 between the

conductive layer [38] 34 and the conductive strips [34] 30. The dimensions of the dielectric material 28, the [conductor] conductive strips 34 and the vias 39 depend on the particular design frequency for the waveguide 12.

Page 13, lines 3-21:

With the high impedance structure 26 on the waveguide's sidewalls such that the conductive strips run parallel to the waveguides longitudinal axis, the structure will present a high impedance to the E field component of a vertically polarized signal at the design frequency. As shown in FIG. 4, the gap 32 presents a capacitance 38 to the E field component that is transverse to the conductive strips. The capacitance 38 is primarily dependant upon the width of the gap 32 between the strips 30 but is also impacted by the dielectric constant of the dielectric material [26] 28. The structure 26 also presents an inductance 40 to a transverse E field, the inductance 40 being dependant primarily on the thickness of the dielectric material 28 and the diameter of the vias 36. At resonant frequency, the structure presents parallel resonant L-C circuits 42 to the vertically polarized signal and, as a result, a high impedance to a transverse E field. The E field maintains uniform power density across the waveguide, during transmission through the waveguide.

Page 13, line 28, to page 14, line 13:

The wall structure 26 also has a shorting switch [38] 39 at each of the gaps 32 that short their respective gap when closed, the details of the switches described below and shown in FIGs. 11-14. When the switches [38] 39 are open, the structure functions as described above, presenting a high impedance to a transverse E field. The

gaps 32 form the capacitive part of the resonant L-C circuits and by closing the switches [38] 39, the gaps 32 and their capacitance are shorted. The conductive strips 30 and closed switches 39 change the characteristics of the structure 26 such that it presents as continuous conductive sheet. The waveguide 12 now has conductive sidewalls along with the conductive top and bottom walls. Because the waveguides physical dimension "A" in FIG. 2 is less than the critical dimension required for the frequency, signal transmission is cut-off and blocked. In the preferred embodiment, the switches [38] 39 in all the waveguides of the shutter switch 10 are closed simultaneously, causing all the waveguides to block transmission of the signal.

Page 16, lines 10-18:

The structure 57 is manufactured using similar materials and processes described above for the embodiment shown in FIGs. [1 and 2] 2 and 3 , and the manufacturing of the shorting switches is described below. By selectively closing the switches on opposing walls of the waveguide 50, the horizontal portion, vertical portion, or both, can be cut-off. A shutter switch constructed of these waveguides can selectively block portions of a cross-polarized beam, or the entire beam.

Page 16, line 12 to page 17, line 4:

[FIGs.] FIG. 7 shows another embodiment of the waveguide 70 used to construct the shutter switch 10. The waveguide has a three-layered high impedance 71 structure its walls 72-75. In alternative embodiment the structure 71 can be on the waveguides sidewalls 72, 74 with its top and

bottom walls 73, 75 being conductive, or the structure can be on the waveguides top and bottom walls 73, 75 with its sidewalls 72, 74 being conductive. The structure 71 can have different numbers of layers, depending on the number of frequencies to be transmitted by the waveguide. The structure 71 shown has three layers and presents a high impedance to transverse E fields at three different resonant frequencies.

Page 20, line 19 to page 21, line 5:

FIGs 10a-10c illustrate how the three signals interact with layers of the new structure 71. An important characteristic of the structure's layers 104, 106, and 108 is that each appears transparent to E fields at frequencies below its design frequency, and the strips appear as a conductive surface to E fields at frequencies above its design frequency. For the highest frequency signal f1, the top layer 108 presents as high impedance resonant L-C circuits to the signal's transverse E field. The strips 110 on second layer 106 appear as a conductive layer and become a "virtual ground" for the top layer 108. Signal f2 is lower in frequency than f1 and, as a result, the first layer 104 is transparent to f2's E field, while the second layer [64] 106 appears as high impedance resonant L-C circuits. The [patches] stips 112 on the third layer appear as a conductive layer, becoming the second layer's virtual ground. Similarly, at f3 the top and second layers 108 and 106 are transparent, but the third layer 104 appears as high impedance resonant L-C circuits, with the conductive layer 114 being ground for the third layer 104.

Page 21, line 29, to page 22, line 12:

Shorting switches 116 are shown as symbols on the top layer of the structure 71 on the [top and bottom walls 73] walls 72-75, and the details of the switches are described below and shown in FIGs. 11-14. If the switches are closed on the top layer on all four of the waveguide's walls, the waveguide 70 is changed from transparent to opaque at all three frequencies. For instance, at the lowest frequency, when the first two layers of the structure appear transparent and closing the switches on the top layer shorts the gap capacitance and causes the signal to see only the conductive surface presented by the top layer's conductive strips and closed switches. The same is true for the next higher frequencies. Closing the switches causes them to see only a conductive surface, cutting off transmission.

Page 22, line 23, to page 23, line 9:

If switches 116 are included at each of the layers (not shown) then different frequencies at different polarizations can be selectively blocked. For example, f3 could be blocked in both polarizations if the switches 116 are closed on the bottom layer 82 (shown in FIG. 8) on all four walls. Only for f3 will the all the layers appear as conductive layers, cutting off transmission at f3. If the shorting switches 116 are closed on the bottom layer 82 on the top and bottom walls 73, 75 only, transmission of the horizontally polarized signal at f3 is blocked, while still transmitting the vertically polarized signals at f3. If the

switches 116 are closed on the bottom layer 82 on the sidewalls, transmission of the vertically polarized signal at f3 is blocked. By selectively closing the switches 116 at the other layers 84, 86, the different frequencies in different polarizations can be blocked.

Page 23, line 25, to page 24, line 7:

FIGs. 11, 12 and [23] 13, show one embodiment of the MEMS shorting switches [112] 132 constructed in accordance with the present invention to short the conductive strips [114] 134 in the high impedance structure [110] 130. The switches [112] 132 are fabricated using generally known micro fabrication techniques, such as masking, etching, deposition, and lift-off. FIG. 11 is a sectional view of the high impedance structure [110] 130 taken transverse to the conductive strips [114] 134. FIG. 12 is a sectional view taken long sectional lines one of the shorting switches [112] 132. Both show high impedance structure's dielectric material [116] 136, vias [118] 138 and conductive layer [120] 140.

Page 24, lines 8-17:

The switches [112] 132 are manufactured by depositing semiconductor layer [120] 140 over the conductive strips [114] 134 and over the exposed surface of the dielectric material [116] 136, the preferred semiconductor material being Si_3N_4. Stand-off isolators [122] 142 are deposited at intervals down the gap between the conductive strips [114] 134 and are preferably formed of an insulator material such

as silicon dioxide. A respective strip of metallic material [124] 144 is mounted over each of the gaps by affixing it on the top of the stand-offs [122] 142 along one of the gaps.

Page 24, lines 18-28:

In operation, each metallic strip [124] 144 has either 0 volts or voltage potential applied, with the preferred potential being 50 volts. With 0 volts applied, the strips [114] 134 remain suspended above their respective gap between the stand off isolators [122] 142 as shown in FIG. 12. The switches are in the "Off" state and the structure [110] 130 presents as a high impedance to the design frequency E field transverse to the conductive strips [114] 134. The gaps between the strips [114] 134 presents a capacitance and the vias [118] 138 present an inductance, with the structure presenting as a series of resonant L-C circuits to the transverse E field.

Page 24, line 29 to page 25, line 10:

Referring now to FIG. 13, to close the switch [112] 132 and short the gap between conductive strips [114] 134 a 50 volt potential is applied to the metallic strips [124] 144. This causes an electrostatic tension between the metallic strips [124] 144 and the respective conductive strips [114] 134 below, pulling the switch strip down such that it makes capacitive contact with the strip [114] 134 on each side of the gap. This provides a conductive bridge across the gap, shorting the gap. With all the metallic strips [124] 144 pulled to the strips [114] 134 below, the high impedance structure appears as a conductive surface to the signal's E field. This switching network consumes very

little and has a very fast closure time on the order of 30 μs.

Page 25, lines 11-19:

FIG 14 shows a high impedance structure [140] 150 with a second embodiment of the shorting switches [142] 152 that utilize varactor diode technology to short the gaps. The varactor diode is an ordinary junction diode that relies on its voltage dependent capacitance. Each varactor switch includes a N+ (highly conducting) layer [144] 154 grown or deposited in the each gap between the conductive strips [146] 156. An N- (moderately conducting) layer [148] 158 is grown on top of top of a portion of the N+ layer [144] 154.

Page 25, lines 20-30:

In fabricating the switches [142] 152, the N+ and N- layers [144] 154 and [148] 158 are etched into mesas that will provide a strip of varactor material along the length of the gaps between the conductive strips [146] 156. The switching of the varactor is controlled by a second conductive strip [150] 160 sitting on an insulator layer [152] 162 that is sandwiched between the second strip [150] 160 and each conductive strip [146] 156. The insulator layer [152] 162 provides a capacitive coupling to conductive strip [146] 156 and the ground plane. Voltage applied to the second strip [150] 160 controls the capacitance of the varactor layer and thus the shorting of the gap.

Page 26, lines 9-27:

FIG. 15 shows millimeter beam transmission system [150] 170 used in various high frequency applications such

as munitions guidance systems (e.g. seeker radar). A transmitter [152] 172 generates a millimeter signal [154] 174 that spreads as it moves from the transmitter. Most of the signal is directed toward a lens [156] 176 that collimates the signal into a beam [157] 177 with little diffraction. The collimated beam travels to a second lens 158 that focuses the beam to a receiver [160] 180. The shutter switch [162] 182 is positioned between a millimeter wave transmitter [152] 172 and receiver [160] 180 such that it intercepts the transmission beam [157] 177. When the shorting switches on the shutter switch's waveguides are open, the shutter switch [162] 182 is transparent to the beam and the signal passes from the transmitter [152] 172 to the receiver [160] 180. When the shorting switches are closed, transmission of the signal through each of the waveguides is cut-off, making the shutter switch [162] 182 opaque to the beam [157] 177 and blocking transmission from the transmitter to the receiver.

Page 26, line 28, or page 27, line 2:

As described above, when the waveguides in the shutter switch [162] 182 have the high impedance structure on the sidewalls and the top and bottom walls, the beam can have horizontal and vertical polarization and the shutter switch [162] 182 can block one or both of the polarizations. When the high impedance structure has multiple layers, the shutter switch can be transparent or block signals at multiple frequencies and at one or both polarizations.

Claims

1. (Amended) A shutter switch for an electromagnetic wave

beam, comprising:

a plurality of waveguides adapted to receive at least part of an electromagnetic beam, said waveguides having sidewalls with alterable impedance properties, said waveguides being adjacent to one another with their longitudinal axes aligned with the propagation of said beam each of said waveguides switchable to alter the impedance properties of its sidewalls to either transmit or block transmission of [their] its respective [portions] portion of said beam.

2. (Amended) A shutter switch for an electromagnetic wave beam, comprising:

a plurality of waveguides adapted to receive at least part of an electromagnetic beam, said waveguides being adjacent to one another with their longitudinal axes aligned with the propagation of said beam, said waveguides switchable to either transmit or block transmission of their respective portions of said beam, [The shutter switch of claim 1,] wherein each of said waveguides comprises:

four wall inside surfaces comprising two opposing sidewalls and a top and bottom wall;

respective high impedance wall structures on at least two opposing walls, said wall structures presenting a high surface impedance to E fields transverse to the waveguide axis and [parallel] tangential to the said opposing wall structure, and a low impedance to E fields parallel to the waveguide axis; and

shorting [switches] arrangements on each said wall structures to short circuit their high impedances;

each of said waveguides having internal dimensions to

cut-off the transmission of its respective portion of said beam when its high impedance wall structure is short circuited to a low impedance state.

3. (Amended) The shutter switch of claim 2, wherein each said high impedance wall structure comprises:

a sheet of dielectric material having two sides;

a conductive layer on one outer side of said dielectric material;

a plurality of mutually spaced conductive strips on the other inner side of said dielectric material, said strips having gaps between adjacent said strips and being aligned parallel to the guide longitudinal axis; and

a plurality of conductive vias extending through said dielectric material between said conductive layer and said conductive strips.

5. (Amended) The shutter switch of claim 3, wherein adjacent pairs of said strips present a capacitance and said dielectric sheet presents an inductance to an electromagnetic beam with an E field transverse and tangential to said conductive strips.

6. (Amended) The shutter switch of claim 5, wherein said conductive strips and dielectric material [form] present a series connection of parallel L-C circuits, resonant at an operating frequency, to an electromagnetic beam with an E field transverse and tangential to said conductive strips.

8. (Amended) The shutter switch of claim 3, wherein said high impedance structure are provided on said waveguide's sidewalls and present a high impedance to the E field component of a [horizontally] vertically polarized guided

beam.

9. (Amended) The shutter switch of claim 3, wherein said high impedance structure are provided on said waveguide's top and bottom walls and present a high impedance to the E field component of a [vertically] horizontally polarized [signal] guided beam.

10. (Amended) The shutter switch of claim 3, wherein said high impedance structure are provided on said waveguide's sidewalls and top and bottom walls and present a high impedance to the E field component of both [horizontally] vertically and [vertically] horizontally polarized beams.

11. (Amended) The shutter switch of claim 3, wherein said shorting [switches] arrangements change said high surface impedance structure to a conductive surface by shorting said gaps between said conductive strips.

12. (Amended) The shutter switch of claim 11, wherein said shorting [switches] arrangements comprise micro electromechanical systems (MEMS) switches.

13. (Amended) The shutter switch of claim 12, wherein each of said MEMS shorting [switches] arrangements comprises a shorting strip suspended over said gap between a respective pair of said conductive strips, said [switch] gap being [closed] shorted by applying a voltage potential [to said shorting strip] to adjacent electrodes creating an electrostatic tension [between it and its respective conductive strips] that pulls said shorting strip down to said conductive strips to form a conductive bridge across said gap between said conductive strips.

14. (Amended) The shutter switch of claim 11, wherein said shorting [switches] comprise <u>varactor</u> diode [switches] in each of said gaps.

15. (Amended) The shutter switch of claim 14, wherein each of said varactor diode [shorting switches creates] <u>places</u> a [high] <u>variable</u> capacitance across its respective said gap [when a zero voltage applied to said diode to short said gap] <u>such that a voltage may be applied to detune the parallel L-C circuits away from said operating frequency thus rendering the high surface impedance to a low impedance state and causing a cut-off state for said guide at said operating frequency.</u>

16. (Amended) The shutter switch of claim 2, wherein said high impedance wall structure comprises:

a plurality of stacked high impedance layers, each presenting a high impedance <u>surface</u> to the E field component of a different respective electromagnetic beam <u>operating</u> frequency and being transparent to the E fields of lower <u>operating</u> frequency signals, and presenting a [conductive] <u>low impedance</u> surface to the E field of higher operating frequency signals; and

the bottommost said layer presenting a high impedance <u>surface</u> to the E field of the lowest frequency of said <u>operating</u> signals, and each succeeding layer presenting a high impedance <u>surface</u> to the E field of successively higher <u>operating</u> frequencies.

18. (Amended) The shutter switch of claim 16, wherein corresponding conductive strips of said high impedance layers are [vertically] <u>aligned along the guide</u>

longitudinal axis and said high impedance layers further comprise conductive vias through said dielectric substrates between said aligned conductive strips and said conductive layer.

20. (Amended) The shutter switch of claim 16, wherein each of said high impedance layers presents a series connection of resonant parallel L-C circuits to the E field of its respective [signal] operating frequency.

22. (Amended) The shutter switch of claim 16, wherein said high surface impedance wall structures are on said waveguide's sidewalls and present a high impedance to the E field component of said different frequency beams having [horizontal] vertical polarization.

23. (Amended) The shutter switch of claim 16, wherein said high impedance wall structures are on said waveguide's top and bottom walls and present a high impedance to the E field component of said different frequency beams having [vertical] horizontal polarization.

24. (Amended) The shutter switch of claim 16, wherein said high impedance structures are on said waveguide's sidewalls and top and bottom walls and present a high impedance to the E field component of said different frequency beams having both [horizontal and vertical] vertical and horizontal polarization.

25. (Amended) The shutter switch of claim [16] 17, [wherein said] further comprising shorting [switches] arrangements on each of said plurality of layers to change said high surface impedances [structure] to a conductive surfaces by

shorting said gaps between said conductive strips.

26. (Amended) The shutter switch of claim 25, wherein said shorting [switches] arrangements comprises micro electromechanical systems (MEMS) switches.

27. (Amended) The shutter switch of claim [25] 26, wherein each of said MEMS [shorting] switches comprises a shorting strip suspended over said gap between a respective pair of said conductive strips, said switch being closed by applying a voltage potential to [said shorting strip] adjacent electrodes creating an electrostatic tension [between it and its respective conductive strips] that pulls said shorting strip down to said conductive strips to form a conductive bridge across said gap between said conductive strips.

28. (Amended) The shutter switch of claim 25, wherein said shorting switches comprise varactor diode [switches] in each of said gaps.

29. (Amended) The shutter switch of claim 28, wherein each of said varactor diode [shorting switches creates] places a [high] variable capacitance across its respective said gap [when a zero voltage applied to said diode to short said gap] such that a voltage may be applied to detune the parallel L-C circuits away from said operating frequency thus rendering said high surface impedance to a low impedance state.

30. (Amended) The shutter switch of claim [25] 28, wherein said shorting [switches] arrangements are closed on selective layers of said high impedance structures to block

transmission one or both polarities of said beam at one or all of said different frequency signals.

31. (Amended) A millimeter beam transmission system, comprising;

an electromagnetic beam transmitter;

an electromagnetic beam receiver;

a shutter switch positioned in the path of said beam between said transmitter and receiver, said shutter switch comprising at least one waveguide positioned to receive at least part of said beam, the longitudinal axis of each [if] of said waveguides aligned with the propagation of said beam, each of said waveguide having sidewalls with alterable impedance properties [being switchable] to either transmit or block transmission of its respective portion of said beam.

33. (Amended) A millimeter beam transmission system, comprising;

an electromagnetic beam transmitter;

an electromagnetic beam receiver;

a shutter switch positioned in the path of said beam between said transmitter and receiver, said shutter switch comprising at least one waveguide positioned to receive at least part of said beam, the longitudinal axis of each if said waveguides aligned with the propagation of said beam, each of said waveguide being switchable to either transmit or block transmission of its respective portion of said beam, [The system of claim 31,] wherein each said waveguide comprises:

four wall inner surfaces comprising two opposing sidewalls and a top and bottom wall;

a high impedance wall structure on at least two

opposing walls of said waveguide, said wall structure presenting a high surface impedance to E fields transverse to the waveguide axis and [parallel] tangential to the wall structure, and a low impedance to E fields parallel to the waveguide axis; and

shorting [switches] arrangements on each said high impedance structure to change the high surface impedance of said structure to a low impedance [conductive] surface.

34. (Amended) The system of claim 33, wherein each said waveguide has inner dimensions such that the transmission of said electromagnetic beam is cut-off when said waveguide sidewalls and top and bottom walls are low impedance [conductive] surfaces.

35. (Amended) The system of claim 33, wherein each said high impedance wall structure comprises:

a sheet of dielectric material having two sides;

a conductive layer on one outer side of said dielectric material;

a plurality of mutually spaced parallel conductive strips on the other inner side of said dielectric material; and

a plurality of conductive vias extending through said dielectric material between said conductive layer and said conductive strips.

37. (Amended) The system of claim 36, wherein said conductive strips, vias and dielectric material [form] present a series connection of parallel L-C circuits to an electromagnetic wave with an E field transverse and tangential to said conductive strips.

38. (Amended) The system of claim 36, wherein said shorting [switches] arrangements change said high surface impedance structure to a [conductive] low impedance surface by shorting said gaps between said conductive strips.

39. (Amended) The system of claim 33, wherein said high impedance wall structure comprises:

a plurality of stacked high surface impedance layers, each presenting a high surface impedance to the E field component of a different respective electromagnetic beam operating frequency and being transparent to the E fields of lower frequency signals, and presenting a [conductive] low impedance surface to the E field of higher frequency signals; and

the bottommost said layer presenting a high surface impedance to the E field of the lowest frequency of said signals, and each succeeding layer presenting a high surface impedance to the E field of successively higher frequencies.

40. (Amended) The system of claim 39, wherein each said layer presents a series connection of resonant parallel L-C circuits to the E field of its respective signal operating frequency.

42. (Amended) The system of claim 39, wherein corresponding conductive strips of said layers are [vertically] aligned along longitudinal axis of said guide and said high impedance structure further comprises conductive vias through said dielectric substrates between said aligned conductive strips and said conductive layer.

43. (Amended) The system of claim 39, wherein said shorting

[switches] arrangements change said high surface impedance structure to a [conductive] low impedance surface by shorting said gaps between said conductive strips.

44. (Amended) The system of claim 33, wherein said high impedance structure are provided on said waveguide's sidewalls and present a high impedance to an a transverse and tangential E field component of [horizontally] vertically polarized beams at one or more operating frequencies.

45. (Amended) The system of claim 33, wherein said high impedance structure are provided on said waveguide's top and bottom walls such that said high impedance structure [and present] presents a high surface impedance to an E field component of a [vertically] horizontally polarized beams at one or more operating frequencies.

46. (Amended) The system of claim 33, wherein said high impedance structures are provide on said waveguide's sidewalls and top and bottom walls and present a high impedance to the E transverse and tangential field components of a [horizontally and vertically] vertically and horizontally polarized beams at one or more operating frequencies.

47. (Amended) The system of claim 46, wherein said shorting [switches] arrangements are closed on selective layers of said high impedance structures to block transmission one or both polarities of said beam at one or all of said different operating frequency signals.

52. (Amended) A method of switching an electromagnetic

beam, comprising:

transmitting said beam through one or more waveguides; and

switching the walls of said waveguides between high surface impedance and low surface impedance states to control the propagation of said beam, [The method of claim 48,] wherein said electromagnetic beam is horizontally [and] and/or vertically polarized, and has different operating frequencies, the switching of the walls between high surface impedance and [conductive] low surface impedance states controls propagation of said beam at different operating frequencies and polarizations.

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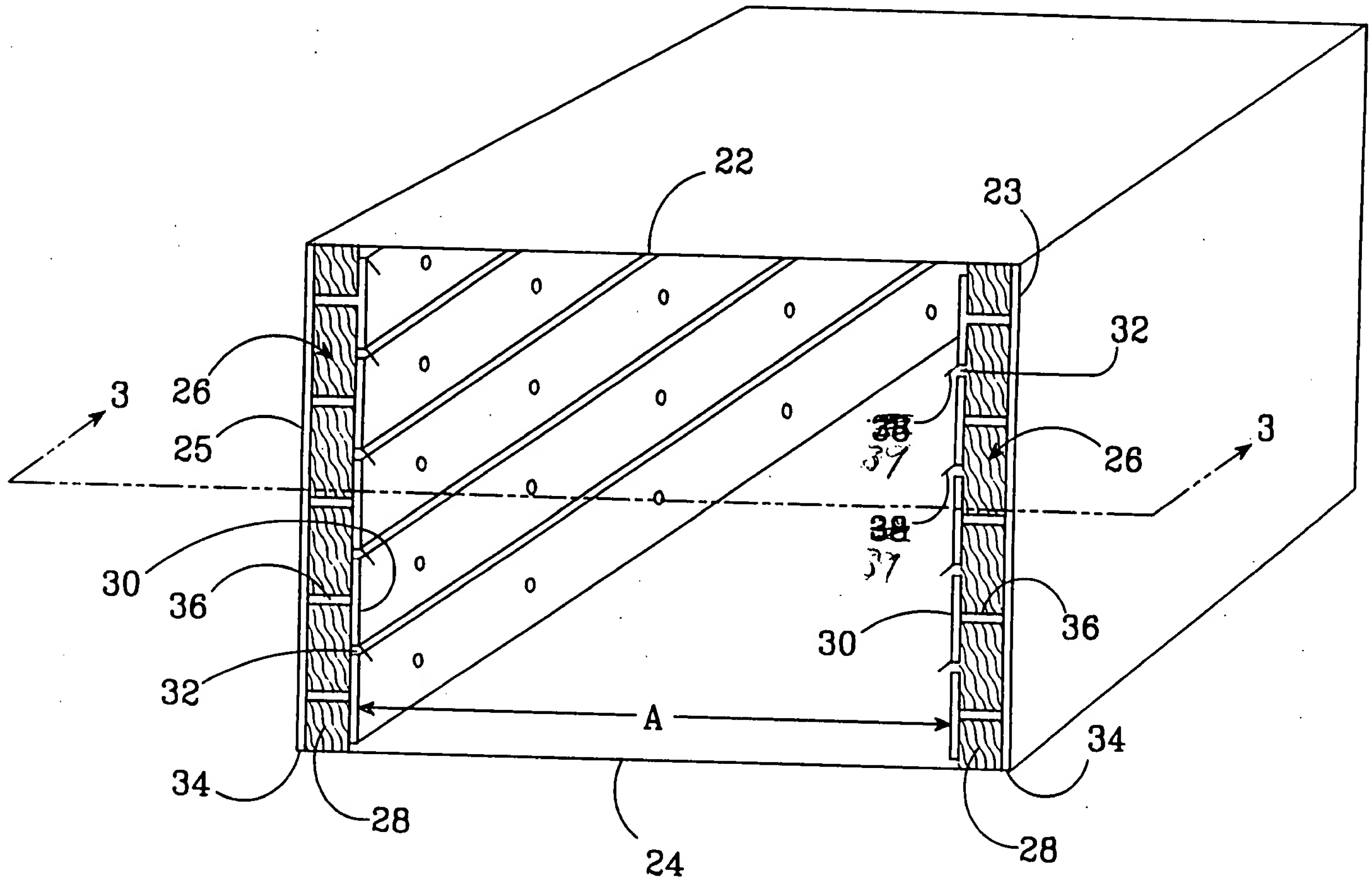

FIG.2

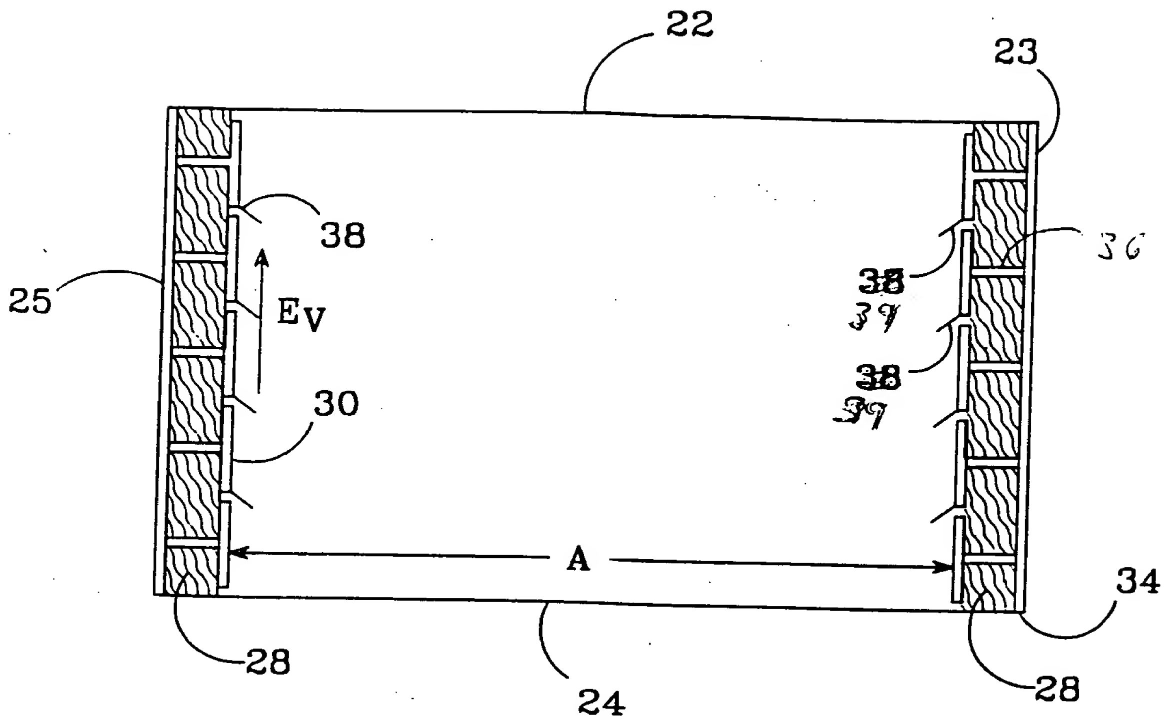
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FIG.3

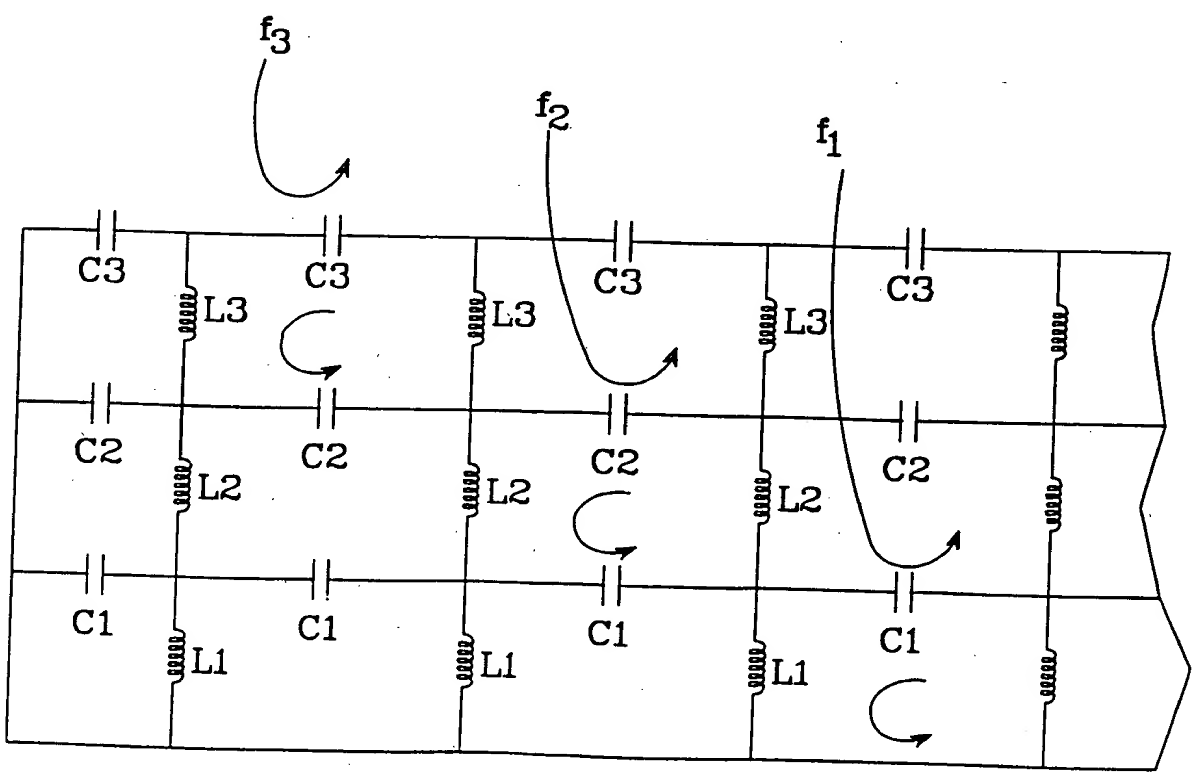
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FIG.9

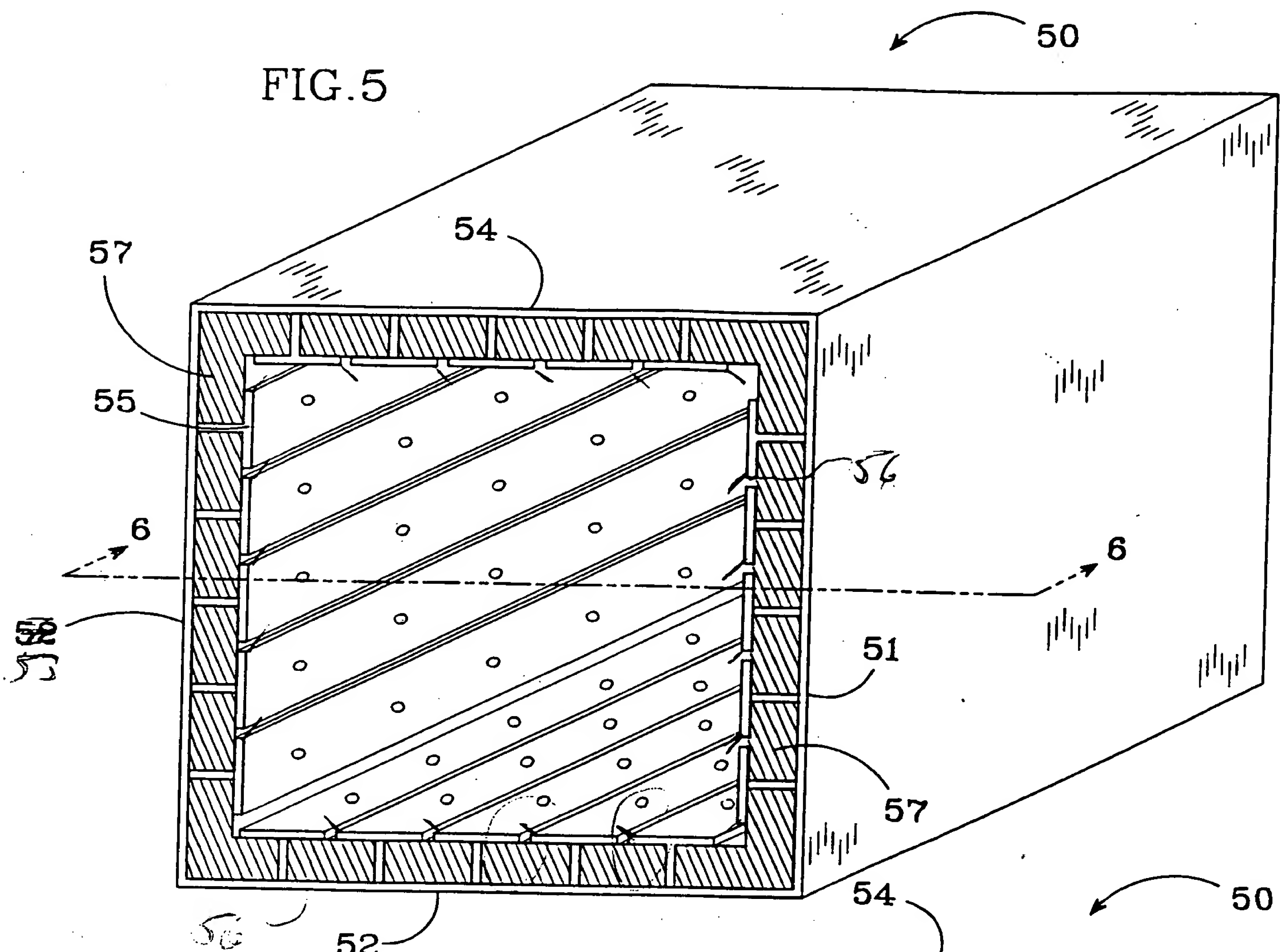

FIG.5

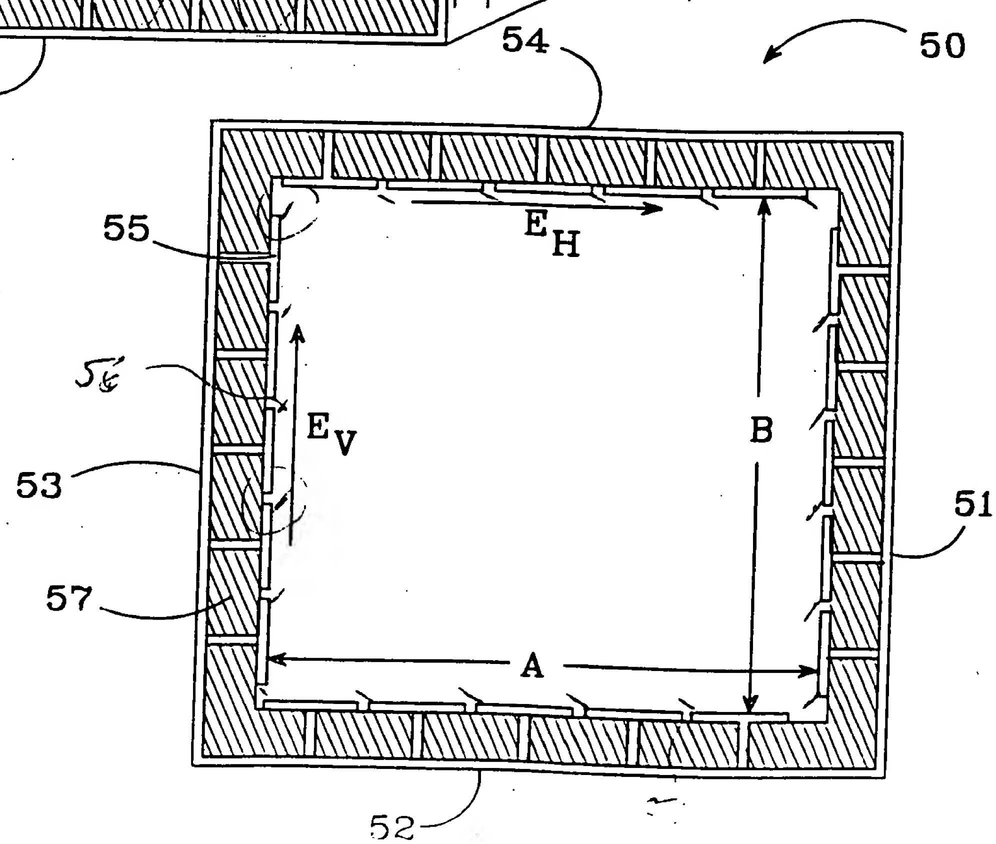

FIG.6

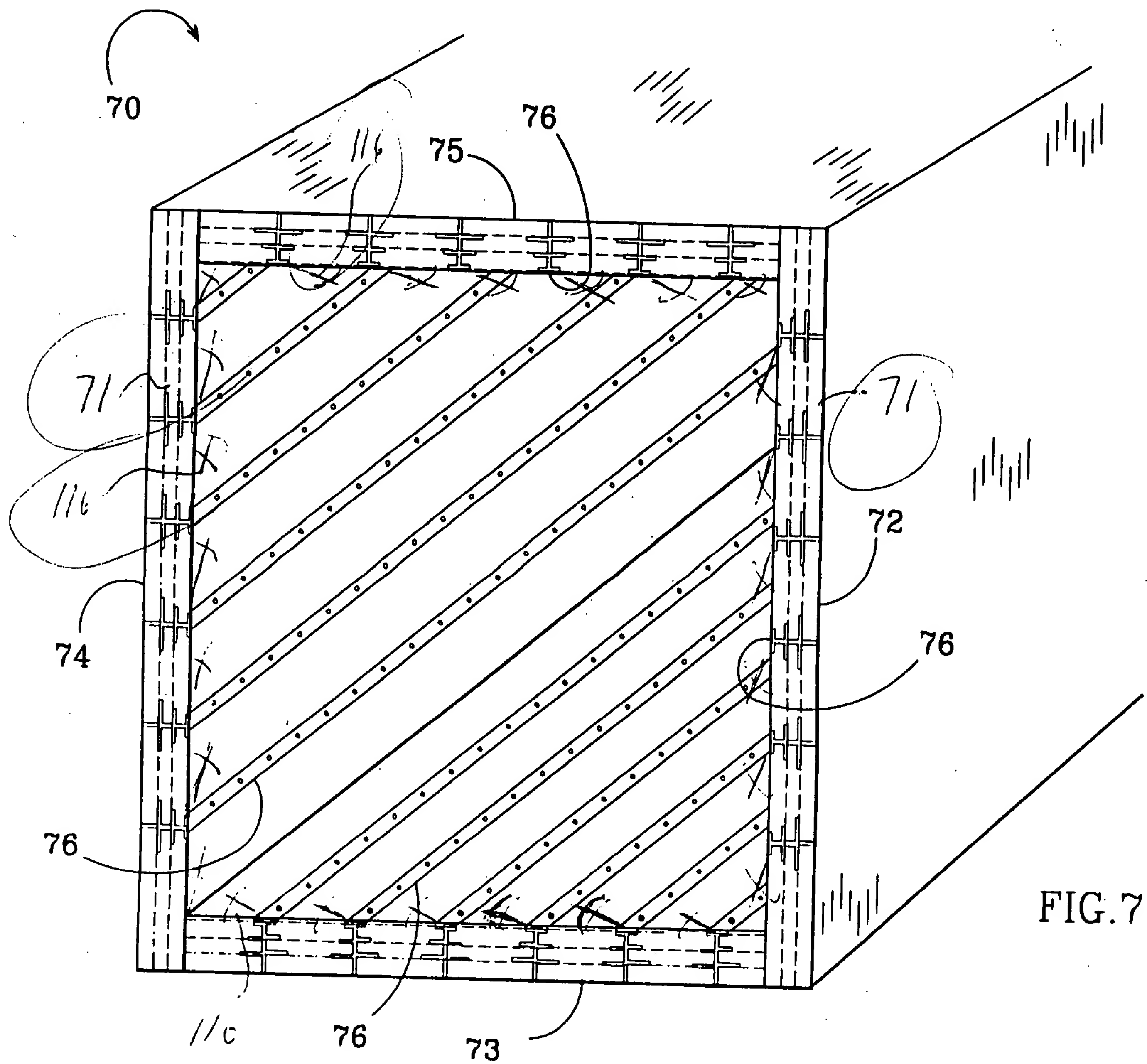

FIG.7

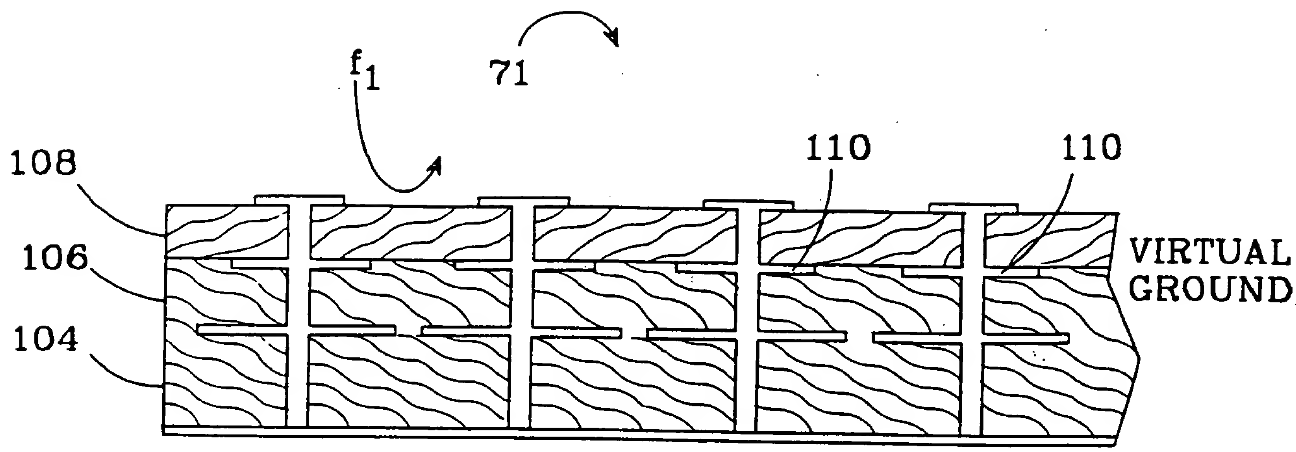

FIG.10a

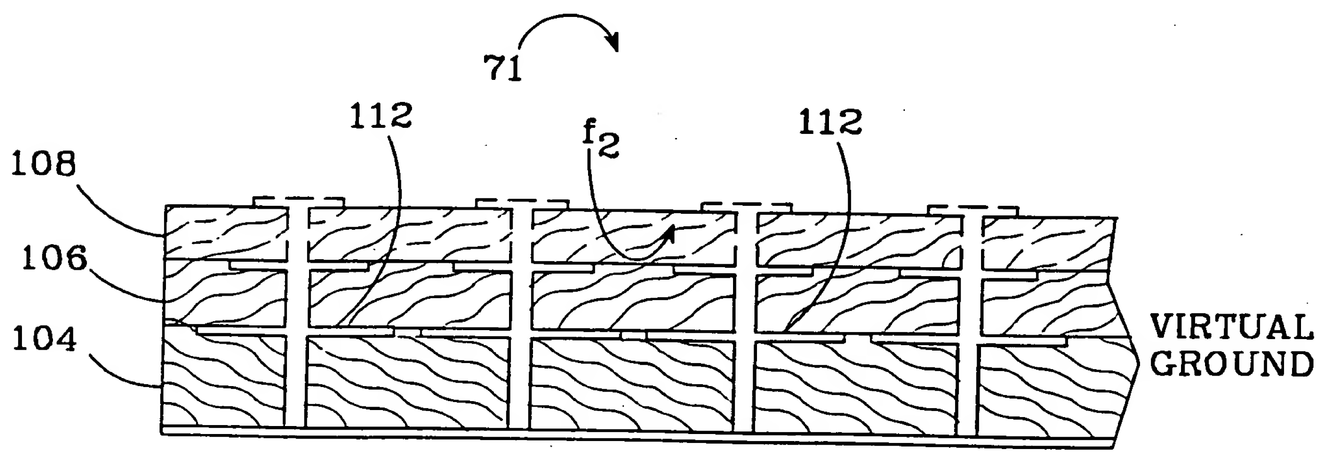

FIG.10b

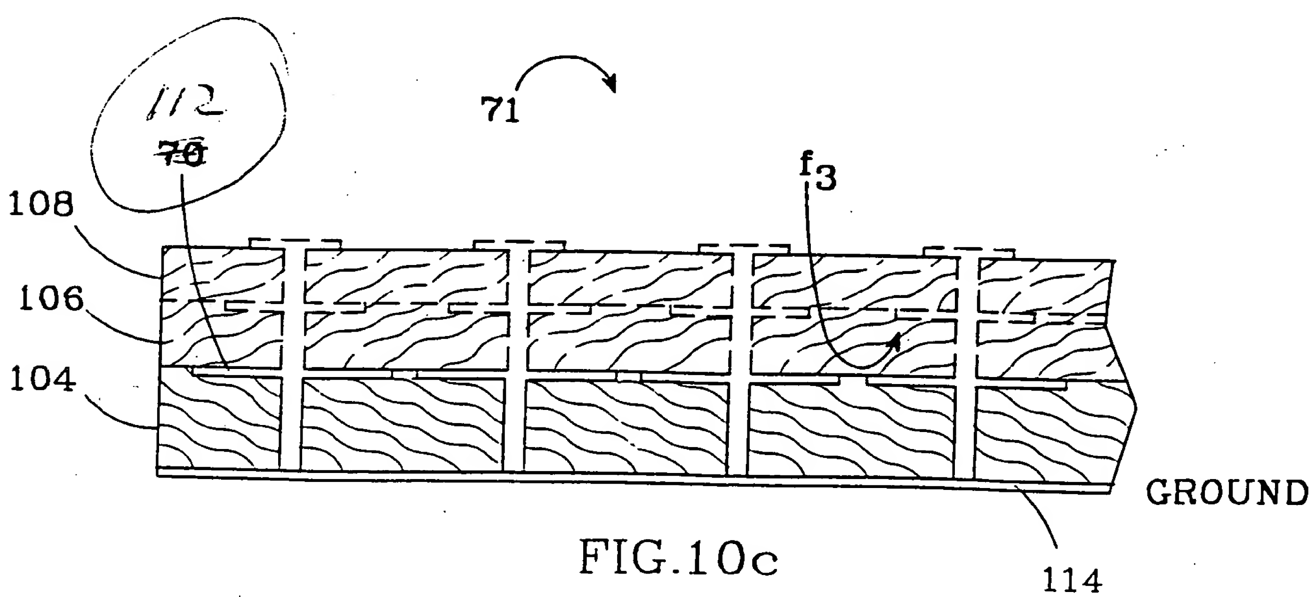

FIG.10c

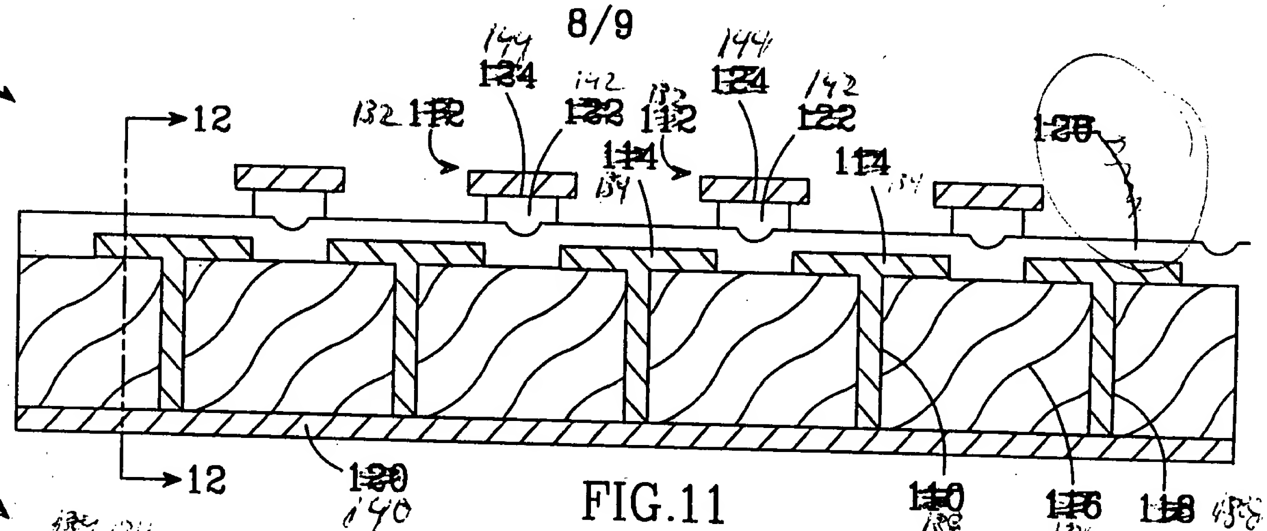

FIG.11

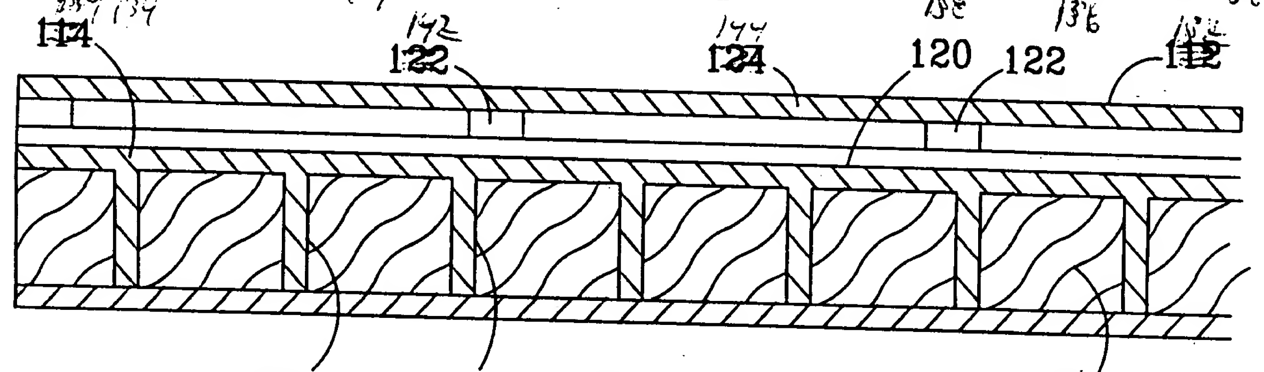

FIG.12

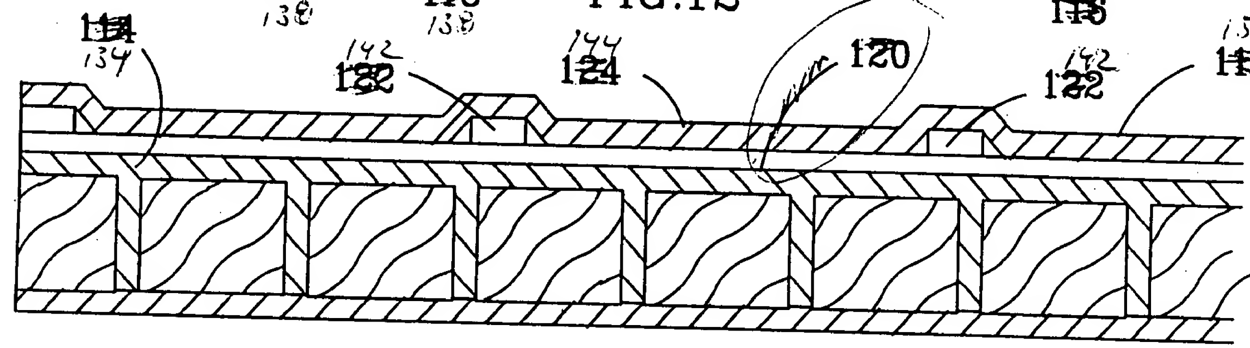

FIG.13

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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7590 01/08/2003

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EXAMINER	
TAKAOKA, DEAN O	
ART UNIT	PAPER NUMBER
2817	

DATE MAILED: 01/08/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

RECEIVED

KOPPEL, JACOBS, PATRICK & HEYBL

CALENDAR ENTRY
ACTION OFFICE ACTION
CALENDARED FOR 4/08/03

PTO-90C (Rev. 07-01)

Office Action Summary	Application No. 09/675,696	Applicant(s) HIGGINS, JOHN A.
	Examiner Dean O Takaoka	Art Unit 2817

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-52* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,31,32 and 48-51* is/are rejected.

7)☒ Claim(s) *2-30,33-47 and 52* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *29 September 2000* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 3 .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Specification

The disclosure is objected to because of the following informalities:

i) Reference number **34**: is disclosed as a "conductive material **34**" (page 11, line 27), "conductive layer **34**" (page 12, line 7), and "conductive strips **34**" (page 12, line 32). With respect to Fig. 2, it appears reference number 30 illustrates "strips" while reference number 34 illustrates a "wall". While the material of 34 may be conductive, it does not appear that 34 is shown as a "strip".

ii) Reference number **38**: is disclosed as a "conductive layer **38**" (page 12, line 32), and "capacitance **38**" (page 13, line 10), and "switches **38**" (page 13, line 31 and page 14, lines 2 and 10). With respect to Figs. 2, 3 and 4, it appears reference number 38 illustrates a tab or switch (Figs. 2 and 3) and capacitance in Fig. 4.

The Examiner requests the description (page 12, line 32 and page 13, line 10) changed to --switch-- for consistency; e.g. (page 12, line 32; --<u>switch **38**</u> comprises a conductive layer--) and (page 13, line 10; --<u>switch **38**</u> forms a capacitance--).

Appropriate correction is required.

Drawings

1) The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference sign(s) not mentioned in the description

i) Figs. 2, 3: reference numbers **23** and **25** do not appear to be disclosed in the specification.

ii) Fig. 7: reference number **76** does not appear to be disclosed in the specification.

2) The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description:

i) Reference number **56** (pages 14 and 15) is not show in Figs. 5 and 6.

ii) Reference number **71** (pages 16 – 18 and 20 – 22) is not show in Fig. 7.

3) The drawings are objected to because: side wall 53 (page 14, line 31) is shown in Fig. 5 as reference number **52**.

4) A proposed drawing correction, corrected drawings, or amendment to the specification to add the reference sign(s) in the description, are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

The applicant is required to provide a copy of the drawings with proposed drawing changes marked in **red ink** as required by 37 CFR 1.121(d).

Claim Objections

Claim 31 is objected to because of the following informalities: The Examiner believes the word "if" (page 34, line 3) should be --of-- (e.g. "the longitudinal axis of each [if] <u>of</u> said waveguides...").

Appropriate correction is required.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claim 1, 31 and 32 are rejected under 35 U.S.C. 102(b) as being anticipated by Stafford (U.S. Patent No. 5,504,575).

<u>Claim 1:</u>

Stafford (Figs. 1 – 5) shows a shutter switch for an electromagnetic wave beam (abstract, spec all where Stafford discloses parallel rays of radiation, radiation inherently electromagnetic, further where the preferred embodiment is used in a magnetooptic modulator – col. 1, line 61) comprising: a plurality of waveguides (92 – Fig. 3) adapted to receive at least part of an electromagnetic beam, the waveguides being adjacent to one another (adjacent optic fibers 92 shown in Fig. 3) with their longitudinal axes aligned with the propagation of the beam, the waveguides switchable to either transmit or block transmission of their respective portions of the beam (col. 4, lines 33 – 53 where switches 93, block radiation of the optical fiber 92 or are selectively opened to allow spectrum analysis).

<u>Claim 31:</u>

A millimeter beam transmission system (inherent in that a optical signal is transmitted, the optical signal inherently being defined as/in millimeter wavelengths) comprising; an electromagnetic beam transmitter (the electronic beam discussed in the reasons for rejection of claim 1 above and the transmitter inherent as source for the transmitted waves thru slit 60 shown in Fig. 3, further exemplified as the source shown in Fig. 4 and 5); an electromagnetic beam receiver (detector 100 – Fig. 3); a shutter switch (shutter switch 93) positioned in the path of the beam between the transmitter

COULD BE AMBIENT

and receiver, the shutter switch comprising at least one waveguide positioned to receive at least part of the beam, the longitudinal axis of each of the waveguides aligned with the propagation of the beam (the longitudinal axis of waveguides 92 shown aligned with the propagation of the beam – Fig. 3), each of the waveguide being switchable to either transmit or block transmission of its respective portion of the beam (the transmission or blocking of the electronic beam discussed in the reasons for rejection of claim 1 above).

Claim 32:

A radiating element for generating a electromagnetic millimeter signal and a first lens (42) positioned to collimate at least a part of the millimeter signal into a beam, and a receive receiver comprises a electromagnetic receiving element and a second lens (48) positioned to focus the beam to the receiving element, the shutter switch positioned between the first and second lenses (SLM 46 – Fig. 2 including shutter switch 93 – Fig. 3).

Claim 48, 49 and 51 are rejected under 35 U.S.C. 102(b) as being anticipated by Kanack (U.S. Patent No. 5,526,172).

Claim 48:

Kanack shows a method of switching an electromagnetic beam (the method inherent in that Kanack shows a final product, inherently formed by a method; further where the method of the claim is generic, thus inherently being shown by the final product of Kanack; further where the generic method, contained in the preamble of the claim is given no patentable weight as the generic method of the claim breaths no life

into the claim) comprising: transmitting the beam through one or more waveguides (the transmission of an electromagnetic beam, inherent in the function of the waveguide and all switches shown by Kanack, the waveguide explicitly shown in Fig. 25a or implicitly by all switch figures in which the waveguide would be defined as the transmission lines of the respective switches); and switching the walls of the waveguide between high impedance and conductive states to control the propagation of selected modes of the beam (where Kanack discloses the functionality of the switch to adjust the impedance with respect to Fig. 18, in which the switch blocks or unblocks the optical path of the transmitted signal – col. 20, line 39 to col. 21, line 13; the high impedance formed in the walls by the deflected member).

Claims 49 and 51:

Where the electromagnetic beam is horizontally and vertically polarized and switching the sidewalls of the waveguide between high impedance and conductive states to control the propagation of the beam (where the horizontal and vertical polarizations are inherent in that the rectangular waveguide (25a) would inherently define the horizontal and vertical polarizations of the transmitted beam, where the switching the sidewalls of the waveguide between high impedance and conductive states is discussed in the reasons for rejection of claim 48 above).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the

invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claim 50 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kanack.

Kanack shows a rectangular wavguide with switches, discussed in the reasons for rejection of claims 48, 49 and 51 above.

Kanack does not show switching the top and bottom walls.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified the waveguide disclosed by Kanack by switching the top and bottom walls of the waveguide. Such a modification would have been a mere optimization of design to achieve a desired signal propagation thus suggesting the obviousness of the modification.

Allowable Subject Matter

Claims 2 – 30, 33 – 47 and 52 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

The following is a statement of reasons for the indication of allowable subject matter: Stafford does not show the waveguides comprising four walled surfaces, high impedance on two opposing walls and low impedance on the other walls, and shorting switches on each of the walled structures (claims 2 and 33).

Kanack does not teach different frequencies of the signal (claim 52).

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Athale – shows an optical switching system.

Jenkins et al. – shows an optical switching system.

Huang – shows an optical switching system.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dean O Takaoka whose telephone number is (703) 305-6242. The examiner can normally be reached on 8:30a - 5:00p Mon - Fri.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Robert Pascal can be reached on (703) 308-4909. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 872-9318 for regular communications and (703) 872-9319 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0956.

dot
January 7, 2003

Robert Pascal
Supervisory Patent Examiner
Technology Center 2800

Serial ______________ Docket No: 00SC033US7

Client ROCKWELL TECHNOLOGIES, LLC

Applicants..JOHN A. HIGGINS.

Title SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS ANI METHOD FOR SWITCHING

On 9-29-00, we mailed:

1. PATENT TRANSMITTAL AND DUPLICATE
2. PATENT APPLICATION WITH DECLARATION AND POWER OF ATTORNEY
3. ASSIGNMENT AND COVER SHEET
4. 9 SHEETS OF DRAWINGS

The PTO received the above on the date stamped on this card.

EL682948722US

Serial 09/675696 Docket No. 00SC033US7

Client ROCKWELL TECHNOLOGIES, LLC

Applicants..JOHN A. HIGGINS.

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September 29, 2000

Assistant Commissioner for Patents
Box Patent Application
Washington, D.C. 20231

Re: SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS AND METHOD FOR SWITCHING
Docket No. 00SC033US7

Sir:

Transmitted herewith for filing under 35 U.S.C. 111 and 37 CFR 1.53 is the patent application of JOHN A. HIGGINS entitled SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS AND METHOD FOR SWITCHING.

Enclosed are:

39 pages of written description, claims and abstract.
9 sheets of drawings plus 2 copies.
An Assignment of the invention to Rockwell Technologies, LLC.
Executed Declaration and Power of Attorney.

The filing and recording fees have been calculated as shown below:

Basic Fee		$690.00
Total Claims	(52 - 20) x $18.00 =	576.00
Independent Claims	(3- 3) x $78.00 =	0.00
Assignment Recording Fee		40.00
	Total Fee:	$ 1,306.00

Please charge Deposit Account No. 18-1750 in the amount of $ 1,306.00 to cover the filing and recording fees. We authorize the Commissioner to charge (1) payment of any additional filing fees required under 37 CFR §1.16, (2) payment of any patent application processing fees under 37 CFR §1.17 associated with this communication, or (3) payment of any fees that occur during the pendency of this application (and to credit any overpayment) to Deposit Account No. 18-1750. We enclose a duplicate copy of this sheet.

Very truly yours,
KOPPEL & JACOBS

Jaye G. Heybl
Registration No. 42,661

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APPLICATION

OF

John A. Higgins

FOR

UNITED STATES LETTERS PATENT

ON

SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS
AND METHOD FOR SWITCHING

Docket No. 00SC033US7

ASSIGNED TO

ROCKWELL TECHNOLOGIES, LLC

SHUTTER SWITCH FOR MILLIMETER WAVE BEAMS AND METHOD FOR SWITCHING

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to millimeter wave beams and more particularly to a switch that either reflects or is transparent to a millimeter beam.

Description of the Related Art

Electromagnetic signals are commonly guided from a radiating element to a destination via a coaxial cable or metal waveguide. As the frequency of the signal increases, the coaxial cable or metal waveguide used to guide the signals have smaller cross-sections. For example, a metal waveguide that is 58.420 cm wide and 29.210 high at its inside dimensions, transmits signals in the range of 0.32 to 0.49 GHz. A metal waveguide that is 0.711 cm wide and 0.356 cm high at its inside dimensions, transmits signals in the range of 26.40 to 40.00 GHz. [Dorf, The Electrical Engineering Handbook, Second Edition, Section 37.2, Page 946 (1997)]. As the signal frequencies continue to increase a point is reached where the coaxial cables and waveguides become impractical. They become too small and expensive and require precision machining to produce. In addition, their insertion can become too great.

High frequency signals in the range of approximately 1 to 50 GHz, can be guided through a microstrip transmission line. However, at frequencies above this range, the microstrip suffers from the same problems; the transmission line becomes too small and the insertion loss from transmission through the line becomes too great.

Frequencies exceeding approximately 100GHz (referred to as millimeter waves) should not be transmitted over a distance by a microstrip transmission line because of the insertion loss. Instead, the signal can be transmitted as a free-space beam. The signal from a radiating element is directed to a lens that focuses the signal into a millimeter wave beam having a diameter up to several centimeters. The beam is transmitted to a receiving lens that focuses the signal to a receiving element which often includes an amplifier. This form of transmission is referred to as "quasi-optic" when the lens diameter divided by the signal wavelength is in the range of approximately 1-10. In the optic regime, the lens diameter divided by the frequency wavelength is normally much greater than 10. [IEEE Press, Paul f. Goldsmith, <u>Quasi-optic Systems</u>, Chapter 1, Gaussian Beam Propagation and Applications (1999)]

For quasi-optic or optic transmission in military or commercial applications, a safety mechanism is normally needed in the beams path in the form of a shutter that either blocks the beam from reaching the component that needs protection, or allows the beam to reach the component. The mechanism is primarily used to protect delicate amplifiers at the receiving end of the transmission line from power surges at the radiating element. Mechanical shutters have been used for this purpose, but they are generally too slow at blocking the beam and are too unreliable because of complex mechanical components.

Another important characteristic of transmission in metal waveguides is the transmission cut-off frequency. If the frequency of the transmitted signal is above the cut-off frequency, the electromagnetic energy can be

transmitted through the guide with minimal attenuation. Electromagnetic energy with a frequency below the cut-off will be totally reflected at entry to the guide and will be attenuated to a negligible value in a relatively short distance through the waveguide. The physical dimensions of a metal waveguide not only determines the range of frequencies that it transmits, but also the cut-off frequency for the fundamental (first) mode. The two waveguides described above have cut-off frequencies of 0.257 GHz and 21.097 GHz, respectively.

A structure has been developed that presents as a high impedance to transverse E fields of electromagnetic signals. [M. Kim et al., A Rectangular TEM Waveguide with Photonic Crystal Walls for Excitation of Quasi-Optic Amplifiers, (1999) *IEEE MTT-S*, Archived on CDROM]. The structure is particularly applicable to the sidewalls and/or top and bottom walls of metal rectangular waveguides. Either two or four of the waveguide's walls can have this structure, depending upon the polarizations of the signal being transmitted. The structure comprises a substrate of dielectric material with parallel strips of conductive material that are separated by small (capacitive) gaps. It also includes inductive metal vias through the sheet to a conductive sheet on the substrate's surface opposite the strips. At a certain frequency the inductance of the vias and the capacitance of the gaps resonate. At this "resonant" frequency, the surface impedance of becomes very high.

When used on a rectangular waveguide's sidewalls, the structure provides a high impedance boundary condition for the E field component of a fundamental mode vertically polarized signal, the E field being transverse to the conductive strips. The high impedance prevents the E field

from dropping off near the waveguide's sidewalls, maintaining an E field of uniform density across the waveguide's cross-section. Current can flow down the waveguide's conductive top and bottom walls to support the signal's H field with uniform density. Accordingly, the signal maintains near uniform power density across the waveguide aperture.

When the high impedance structure is used on all four of the waveguide's walls, the waveguide can transmit independent cross-polarized signals each one being similar to a free-space wave having a near-uniform power density. The structure on the waveguide's sidewalls presents a high impedance to the E field of the vertically polarized signal, while the structure on the waveguide's top and bottom walls presents a high impedance to the horizontally polarized signal. The structure also allows conduction through the strips to support the signal's H field component of both polarizations. Thus, a cross-polarized signal of uniform density can be transmitted.

Waveguides employing these high impedance structures are also able to transmit signals close to the resonant frequency that would otherwise be cut-off because of the waveguide's dimensions if all of the waveguide's walls were conductive. At resonant frequency, the waveguide essentially has no cut-off frequency and can support uniform density signals when its width is reduced well below the width for which the frequency being transmitted would be cut-off in a metal waveguide.

SUMMARY OF THE INVENTION

The present invention provides a new millimeter beam shutter switch that is placed in a millimeter beams path and is either opaque and blocks the beam, or is transparent

and allows the beam to pass with minimal attenuation. The new switch can change states between opaque and transparent in microseconds or less without employing complicated or unreliable mechanical components.

The new shutter switch includes a plurality of waveguides adapted to receive at least part of the electromagnetic beam. The waveguides are adjacent to one another with their longitudinal axes aligned with the propagation of the beam. The waveguides switchable to either transmit or block the transmission of their respective portions of the beam.

The new shutter switch uses rectangular waveguides with high impedance structures on at least two opposing interior walls. The high impedance structures allow smaller waveguides to transmit signals that would otherwise be cut-off if all of the waveguide's walls were conductive. The cross-section of each individual waveguide can be smaller than the beam's cross-section, and the shutter switch includes a sufficient number of waveguides to intercept the entire beam. The waveguides are mounted adjacent to one another to form a wall, with each of the waveguide's longitudinal axes aligned with the millimeter beam's propagation axis. Each of the high impedance structures has shorting switches that, when closed, cause the structure to change from a high impedance surface to a conductive surface.

One embodiment of the shutter switch uses waveguides that have high impedance structures on their sidewalls, which allows each of the waveguides to transmit uniform density, vertically polarized signals at a particular design frequency. The preferred high impedance sidewalls comprise a sheet of dielectric material with a conductive layer on one side. The opposite side of the dielectric

material has a series of parallel conductive strips that are oriented down the waveguide's longitudinal axis. Each of the strips has a uniform width, with uniform gaps between adjacent strips. Vias of conductive material are provided through the dielectric material between the conductive layer and the conductive strips. The actual dimensions of the surface structure depend on the materials used and the signal frequency.

During transmission of a vertically polarized signal, the waveguide carries an E field component transverse to the surface structure's conductive strips. At a design frequency, the vias which extend through the substrate present an inductive reactance ($2\pi fL$), while the gaps between the strips present an approximately equal capacitive reactance ($1/(2\pi fC)$). The surface presents parallel resonant L-C circuits to the transverse E field component; i.e. a high impedance. The L-C circuits present an open-circuit to the transverse E-field, allowing it to remain uniform across the waveguide. The low impedance on the top and bottom waveguide walls allows current to flow and maintains a uniform H field. Each of the waveguides transmits the signal with uniform density, and the shutter switch appears transparent to the vertically polarized beams at the design frequency.

When the shorting switches on the high impedance structure are closed, the high impedance sidewalls are switched to a conductive surface. All of the waveguide's walls become conductive and, because of the waveguide's dimensions, signal transmission is cut-off. If the shorting switches are closed in all of the shutter switch's waveguides, transmission is blocked in all the waveguides and the shutter switch becomes opaque to the beam.

Similarly, if the shutter switch has waveguides with the high impedance structure on the top and bottom walls, the shutter switch could be used to block or transmit horizontally polarized signals.

In another embodiment of the waveguide used to form a shutter switch, the high impedance structure is placed on all four of the waveguides walls. This allows the waveguide to transmit a cross-polarized signal (vertical and horizontal) at a particular resonant frequency. When the shorting switches are closed on the high impedance structure in all the waveguides, the shutter switch blocks transmission of the cross-polarized signal. The shorting switches can also be selectively closed to block transmission of only one polarization of the cross polarized signal. Closing the shorting switches on the waveguide's sidewalls blocks the vertically polarized signal, while closing the shorting switches on the top and bottom walls blocks the horizontally signal.

In still another embodiment, either two or all four of the waveguides sidewalls have a multi-layered high impedance structure which causes each of the layers to present a high impedance to a transverse E field at widely separated resonant frequencies. The number of frequencies that the waveguide can transmit with uniform density depends on the number of layers in the structure. When the multi-layered structure is on the sidewalls only, the waveguide transmits vertically polarized signals; when the multi-layered structure on the top and bottom walls, the waveguide transmits horizontally polarized signals. When the multi-layered structure is on all four of the waveguide's wall, the waveguide can transmit either a single polarized signal or both cross-polarized signals. Shorting switches on the multi-layered structures can be

selectively closed to block transmission of one or both of the polarizations, at one of the different transmission frequencies.

Different shorting switches can be used to switch the high impedance surface structures to a conductive surface. The preferred switches consume a relatively small amount of power and employ varactor layer diode technology or micro electromechanical system (MEMS) technology.

These and other further features and advantages of the invention will be apparent to those skilled in the art from the following detailed description, taken together with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of one embodiment of the new waveguide wall shutter switch;

FIG. 2 is a perspective view of one of the waveguides in the shutter switch of FIG.1, the waveguide having a high impedance structure on its sidewalls;

FIG. 3 is a sectional view of the waveguide in FIG.2, taken along section lines 2-2;

FIG. 4 shows the sidewall's high impedance resonant L-C circuits to a transverse E-field;

FIG. 5 is a perspective view of a second embodiment of the waveguide with a high impedance structure on all its walls;

FIG. 6 is a sectional view of the waveguide in FIG. 5 taken along section lines 6-6;

FIG. 7 is a perspective view of a third embodiment of the waveguides with a layered high impedance structure on all of its walls;

FIG. 8 is a sectional view of layered high impedance structure;

FIG. 9 is a diagram of L-C circuits formed by the layered wall structure in response to the E fields of three different frequencies;

FIGs. 10a-10c are sectional views of a three-layer embodiment of the invention, illustrating how three different frequencies interact with the different layers;

FIG. 11 is a sectional view of the high impedance structure with MEMS switches to short the gaps between the conductive strips;

FIG. 12 is a sectional view of the structure shown in FIG. 11, taken along section lines 12-12;

FIG. 13 is the sectional view of the structure shown in FIG. 12 with the switches in the closed state;

FIG. 14 is a sectional view of the high impedance structure with semiconductor varactor layers to short the gaps between the conductive strips; and

FIG. 15 shows the new shutter switch used in millimeter beam transmission.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a new waveguide wall shutter switch 10 constructed in accordance with the present invention. It has individual waveguides 12 that are mounted adjacent to one another to form a rectangular wall resembling a honeycomb. The shutter switch 10 is placed in the path of a millimeter beam of a particular resonant frequency and depending on whether the shutter switch is "on" or "off" it either blocks the beam or to allow to pass through. The shutter switch can have different cross-sections depending on the beam's cross-section and whether the entire beam is to be intercepted. For instance, additional waveguides can be included on the top, bottom and sides, to give the shutter switch 10 more of a circular cross-section.

The cross-section of each waveguide 12 is small enough that if all the waveguide's walls were conductive, transmission of the beam at a design frequency would be cut-off. To allow transmission, the waveguides 12 have structures 14 on two of their interior sidewalls that present are aligned with the signal's E field and present as a high impedance to the E field. The high impedance structure also has shorting switches that change the structure's 14 characteristics such that it appears as a conductive surface. When the switches are closed in all the waveguides in the shutter switch 10, the walls in each waveguide become conductive and because of the dimensions of each waveguide transmission of the signal is cut-off. The shutter switch 10 becomes opaque, blocking transmission of the beam.

A portion of the incoming beam can reflect off the front edges of the waveguides 12, degrading the signal. To reduce this reflection, each waveguide 12 can include a launching region 15 on each waveguide wall that has the high impedance structure. The launching region begins at the entrance of each waveguide 12 and continues for a short distance down the waveguide. It is similar to the thumbtack high impedance structure described above, and comprises "patches" of conductive material mounted in a substrate of dielectric material. "Vias" of conducting material running from each patch to a continuous conductive sheet on the opposite side of the dielectric substrate.

The launching region resonates at the frequency of the beam entering the waveguides in the module. The vias which extend through the substrate present an inductive reactance (L), while the gaps between the patches present an approximately equal capacitive reactance (C). The surface presents parallel resonant high impedance L-C circuits to

the beams E field component The L-C circuits present an open-circuit to the E-field, allowing it to remain uniform across the waveguide. The low impedance on the top and bottom waveguide walls allows current to flow and maintains a uniform H field.

The gaps between the patches block surface current flow in all directions, preventing surface waves in the high impedance structures. This blocks TM and TE modes from entering the waveguide 12, only allowing TEM modes to enter. Blocking the TM and TE modes reduces the front edge reflection and the front edge of the waveguide appears nearly transparent to the beam at the resonant frequency.

In describing the various embodiments of the individual waveguides below, the launching region is not discussed or shown. However, to reduce reflection in any module comprised of the waveguides below, each waveguide should include a launching region.

Single Polarization Beams

FIGs. 2 and 3 show one embodiment of the waveguide 12 used to construct the shutter switch 10. Its top and bottom walls 22 and 24 are conductive, and its sidewalls have high impedance structure 26. The structure 26 includes a sheet of dielectric material 28 with conductive strips 30 of uniform width on one side, the conductive strips 30 having a uniform gap 32 between adjacent strips 30. A layer of conductive material 34 is included on the side of the dielectric material 28 opposite the conductive strips 30. Vias 36 of conductive material are provided between the conductive strips 30 and the conductive layer 34, through the dielectric material 28. The conductive strips 32 are oriented longitudinally down the waveguide 12.

The wall structure 26 is manufactured using known

methods and known materials. Numerous materials can be used as the dielectric material 28 including but not limited to plastics, poly-vinyl carbonate (PVC), ceramics, or high resistance semiconductor material such as Gallium Arsenide (GaAs), all of which are commercially available. Highly conductive material must be used for the conductive strips 30, conductive layer 34, and vias 36, and in the preferred embodiment all are gold.

The wall structure 26 is manufactured by first vaporizing a layer of conductive material on one side of the dielectric material 28 using any one of various known methods such as vaporization plating. Parallel lines of the newly deposited conductive material are etched away using any number of etching processes, such as acid etching or ion mill etching. The etched lines (gaps) are of the same width and equidistant apart, resulting in parallel conductive strips 30 on the dielectric material 28, the strips 30 having uniform width and a uniform gap 32 between adjacent strips.

Holes are created through the dielectric material 28 at uniform intervals, the holes continuing through the dielectric material 28 to the conductive strips 30 on the other side. The holes can be created by various methods, such as conventional wet or dry etching. They are then filled or covered with the conductive material and the uncovered side of the dielectric material is covered with a conductive material, both accomplished using sputtered vaporization plating. The holes do not need to be completely filled but the walls of the holes must be covered with the conductive material. The covered or filled holes provide conductive vias 39 between the conductive layer 38 and the conductive strips 34. The dimensions of the dielectric material, the conductor strips and the vias

depend on the particular design frequency for the waveguide 12.

With the high impedance structure 26 on the waveguide's sidewalls such that the conductive strips run parallel to the waveguides longitudinal axis, the structure ~~will~~ presents a high impedance to the E field component of a vertically polarized signal at the design frequency. As shown in FIG. 4, the gap 32 presents a capacitance 38 to the E field component that is transverse to the conductive strips. The capacitance 38 is primarily dependant upon the width of the gap 32 between the strips 30 but is also impacted by the dielectric constant of the dielectric material 26. The structure 26 also presents an inductance 40 to a transverse E field, the inductance 40 being dependant primarily on the thickness of the dielectric material 28 and the diameter of the vias 36. At resonant frequency, the structure presents parallel resonant L-C circuits 42 to the vertically polarized signal and, as a result, a high impedance to a transverse E field. The E field maintains uniform power density across the waveguide, during transmission through the waveguide.

Current can flow along the top and bottom waveguide walls in the direction of propagation and as a result, the design frequency signal also maintains a uniform H field during transmission. With a uniform density E and the H field, the signal maintains uniform power density through transmission, with minimal attenuation.

The wall structure 26 also has a shorting switch 38 at each of the gaps 32 that short their respective gap when closed, the details of the switches described below and shown in FIGs. 11-14. When the switches 38 are open, the structure functions as described above, presenting a high impedance to a transverse E field. The gaps 32 form the

capacitive part of the resonant L-C circuits and by closing the switches 38, the gaps 32 and their capacitance are shorted. The conductive strips and closed switches change the characteristics of the structure such that it presents as continuous conductive sheet. The waveguide 12 now has conductive sidewalls along with the conductive top and bottom walls. Because the waveguides physical dimension "A" in FIG. 2 is less than the critical dimension required for the frequency, signal transmission is cut-off and blocked. In the preferred embodiment, the switches 38 in all the waveguides of the shutter switch 10 are closed simultaneously, causing all the waveguides to block transmission of the signal.

Cross-polarized Beams

FIGs. 5 and 6 show a second embodiment of a waveguide 50 used to construct the shutter switch. It operates similarly to the waveguide in FIGs. 1 and 2, but can block one or both polarizations (horizontal and vertical) if they are simultaneously present.

The waveguide 50 has the high impedance structure 57 on all four walls 51-54, with the corresponding shorting switches 56 at each gap between the conductive strips 55. The conductive strips 55 are oriented longitudinally down the waveguide 50. The structure on all four walls 51-54 allows the waveguide 50 to simultaneously transmit signals with horizontal and vertical polarizations while maintaining a uniform power density. The signal with vertical polarization will have an E field with uniform density as a result of the high impedance presented by the structure 57 on the sidewalls 51 and 53. Current flows

along the strips of the structure on the waveguide's top wall 54 and/or bottom wall 52 of the waveguide, maintaining a uniform H field. For the portion of the signal having horizontal polarization, the E field maintains uniform power density because of the wall structure at the top wall 54 and bottom wall 52, and the H field remains uniform because of current flowing along the strips of the sidewalls 51 and 53. Thus, when the waveguide is transmitting, the power density of the cross polarized signal is uniform across the waveguide.

Closing all the switches 56 on all of the waveguide's walls causes them to appear as conductive surfaces. The waveguide will appear as a metal waveguide to both polarizations and because of the waveguide's dimensions A and B, transmission will be cut-off and blocked.

However, closing the switches on the waveguide's sidewalls 51, 53 only causes the waveguide 50 to appear as a metal waveguide to the vertically polarized signal and blocks only that portion of the cross-polarized signal. The E field of the vertically polarized signal is transverse to the conductive strips 55 on the waveguide's sidewalls 51, 53, and the sidewalls with present as a high impedance series of L-C circuits. However, closing the switches 56 on the sidewalls 51, 53 causes them to appear as a conductive surface to the signal's E field. For the H field component of the vertically polarized signal, current runs down the strips 55 on the top and bottom walls 52, 54. As a result, the waveguide 50 appears as though all its wall are conductive and the transmission of the vertically polarized

signal is cut-off.

Similarly, for the horizontally polarized signal, the top and bottom walls 52, 54 appear as a high impedance to the E field, maintaining its uniform density, and the strips 55 on the sidewalls 51, 53 allow current to flow, maintaining a uniform H field. When the switches are closed on the top and bottom walls 52, 54, all of the waveguide's walls will appear conductive to the horizontally polarized signal, and transmission of that portion will be cut-off.

The structure 57 is manufactured using similar materials and processes described above for the embodiment shown in FIGs. 1 and 2, and the manufacturing of the shorting switches is described below. By selectively closing the switches on opposing walls of the waveguide 50, the horizontal portion, vertical portion, or both, can be cut-off. A shutter switch constructed of these waveguides can selectively block portions of a cross-polarized beam, or the entire beam.

Multi-frequency Single and Cross-Polarized Beams

FIGs. 7 shows another embodiment of the waveguide 70 used to construct the shutter switch 10. The waveguide has a three-layered high impedance 71 structure its walls 72-75. In alternative embodiment the structure 71 can be on the waveguides sidewalls 72, 74 with its top and bottom walls 73, 75 being conductive, or the structure can be on the waveguides top and bottom walls 73, 75 with its sidewalls 72, 74 being conductive. The structure 71 can have different numbers of layers, depending on the number

of frequencies to be transmitted by the waveguide. The structure 71 shown has three layers and presents a high impedance to transverse E fields at three different resonant frequencies.

Referring to FIG. 8, each of the layers 82, 84, 86 in the structure 71 include respective dielectric substrates 88, 90, 92 that are progressively thinner from the bottom layer 82 to the top 86. Conductive strips 94, 96, 98 are provided respectively on each of the substrates 82, 84, 86 and their width is progressively smaller from the bottom layer to the top. The strips in each layer are parallel and aligned over the strips in the layers below and above, and preferably have uniform width and a uniform gap between adjacent strips. Because the width of the strips 94, 96, 98 progressively decreases for each successive layer, the gaps between adjacent strips progressively increases. The higher frequency strips with smaller dimensions are situated on the upper layers. In an alternative embodiment, (not shown) there may be as many as three to five higher frequency strips positioned on each lower frequency strip.

The structure 71 includes vias 100 that connect each vertically aligned set of strips to a ground plane conductive layer 102 located at the underside of the bottom layer 82. The preferred vias 100 are equally spaced down the longitudinal centerlines of the strips 94, 96, 98. Alternatively, the location of the vias 50 can be staggered for adjacent strips.

The structure 71 is formed by stacking the layers 82, 84, 86 after their dielectric substrates have been metalized. Numerous materials can be used for the

dielectric substrates, including but not limited to plastics, poly-vinyl carbonate (PVC), ceramics, or high resistance semiconductor materials such as Gallium Arsenide (GaAs), all of which are commercially available. Each layer in the structure 71 can have a dielectric substrate of a different material and/or a different dielectric constant. A highly conductive material such as copper or gold (or a combination thereof) should be used for the conductive layer 102, strips 94, 96, 98, and vias 100.

The strips 94, 96, 98 on each layer are formed prior to stacking by first depositing a layer of conductive material on one surfaces of each dielectric substrate 88, 90, 92. Parallel gaps in the conductive material are then etched away using any of a number of etching processes such as acid etching or ion mill etching. Within each layer, the etched gaps are preferably of the same width and the same distance apart, resulting in parallel conductive strips on the dielectric substrate of uniform width and with uniform gaps between adjacent strips.

The different layers 82, 84, 86 are then stacked with the strips for each layer aligned with corresponding ones in the layers above and below, resulting in aligned strips 94, 96, 98. The layers 82, 84, 86 are bonded together using any of the industry standard practices commonly used for electronic package and flip-chip assembly. Such techniques include solder bumps, thermos-sonic bonding, electrically conductive adhesives, and the like.

Once the layers 82, 84, 86 are stacked, holes are formed through the structure for the vias 100. The holes can be created by various methods, such as conventional wet or dry etching. The holes are then filled or at least lined with the conductive material and preferably at the same time, the exposed surface of the bottom substrate is

covered with a conductive material to form conductive layers 102. A preferred processes for this is sputtered vaporization plating. The holes do not need to be completely filled, but the walls must be covered with the conductive material sufficiently to electrically connect the ground plane to the radiating elements of each layer.

Each of the layers 82, 84, 86 presents a pattern of parallel resonant L-C circuits and a high impedance to an E field for different resonant frequencies. The bottom most layer 82 presents a high impedance to the lowest frequency and the top most layer 86 presents as a high impedance to the highest frequency. To present the high impedance, at least a component of, and preferably the entire E field, must be transverse to the strips 94, 96, 98. A signal normally incident on this structure will ideally be reflected with a reflection coefficient of +1 at the resonant frequency, as opposed to a -1 for a conductive material.

Like the embodiments described above, the capacitance of each layer 82, 84, 86 is primarily dependant upon the widths of the gaps between adjacent strips or patches, but is also impacted by the dielectric constants of the respective dielectric substrates. The inductance is primarily dependent upon the thickness of the substrates 88, 90, 92 and the diameter of the vias 100.

The dimensions and/or compositions of the various layers 82, 84, 86 are different to produce the desired high impedance to different frequencies. To resonate at higher frequencies, the thickness of the dielectric substrate can be decreased, or the gaps between the conductive strips can be increased. Conversely, to resonate at lower frequencies the thickness of the substrate can be increased or the gaps between the conductive strips or patches can be decreased.

Another contributing factor is the dielectric constant of the substrate, with a higher dielectric constant increasing the gap capacitance. These parameters dictate the dimensions of the structure 71. Accordingly, the layered high impedance ground plane structures described herein are not intended to limit the invention to any particular structure or composition.

FIG. 9 illustrates the network of capacitance and inductance presented by a new three layer structure which produces an array of resonant L-C circuits to three progressively higher frequencies f1, f2 and f3. The bottommost layer appears as a high impedance surface to signal f1 as a result of a series of resonant L-C circuits, with L1/C1 representing the equivalent inductance and capacitance presented by the bottommost layer to its design frequency bandwidth. The second and third layers also for respective series of resonant L-C circuits L2/C2 and L3/C3, at their frequency bandwidths.

FIGs 10a-10c illustrate how the three signals interact with layers of the new structure 71. An important characteristic of the structure's layers 104, 106, and 108 is that each appears transparent to E fields at frequencies below its design frequency, and the strips appear as a conductive surface to E fields at frequencies above its design frequency. For the highest frequency signal f1, the top layer 108 presents as high impedance resonant L-C circuits to the signal's transverse E field. The strips 110 on second layer 106 appear as a conductive layer and become a "virtual ground" for the top layer 108. f2 is lower in frequency than f1 and, as a result, the first layer 104 is transparent to f2's E field, while the second layer 64 appears as high impedance resonant L-C circuits. The patches 112 on the third layer appear as a conductive

layer, becoming the second layer's virtual ground. Similarly, at f3 the top and second layers 108 and 106 are transparent, but the third layer 104 appears as high impedance resonant L-C circuits, with the conductive layer 114 being ground for the third layer 104.

Referring again to FIG. 7, the new layered structure 71 is mounted on the interior of all four walls 72-75, with the conductive strips 76 oriented inward and longitudinally down the waveguide. The layered structure 71 allows the waveguide 70 to transmit signals at multiple frequencies, with uniform density at both horizontal and vertical polarizations. For a three layered structure, the waveguide can transmit three different frequencies, with each of the layers responding to a respective frequency.

The vertically polarized signal maintains a uniform density as a result of the high impedance presented by the wall structure on the sidewalls 72, 74 and current flowing along the strips 76 on the top wall 75 and/or bottom wall 76. The horizontally polarized signal maintains uniform power density because of the layered structure at the top and bottom wall 75,76, and current flowing down the conductive strips 76 of the sidewalls 72 and 74. Thus, the cross-polarized signal has a generally uniform power density across the waveguide. If the waveguide is transmitting a signal in one polarization (vertical or horizontal), it only needs the new layered structure on only two opposing walls to maintain the signals uniform power density.

Shorting switches 116 are shown as symbols on the top layer of the structure 71 on the top and bottom walls 73,

the details of the switches are described below and shown in FIGs. 11-14. If the switches are closed on the top layer on all four of the waveguide's walls, the waveguide 70 is changed from transparent to opaque at all three frequencies. For instance, at the lowest frequency, when the first two layers of the structure appear transparent and closing the switches on the top layer shorts the gap capacitance and causes the signal to see only the conductive surface presented by the top layer's conductive strips and closed switches. The same is true for the next higher frequencies. Closing the switches causes them to see only a conductive surface, cutting off transmission.

Closing the shorting switches 116 on the sidewalls 72, 74 blocks transmission of vertically polarized signals at all three frequencies. The structure on the top and bottom presents as a high impedance to the E field of horizontally polarized signals and the waveguide still transmits the horizontal signals at all three design frequencies. The shorting switches 116 are closed on the top and bottom walls 73, 75 to block transmission of the horizontally polarized signals, while still transmitting the vertically polarized signals at all three frequencies.

If switches 116 are included at each of the layers (not shown) then different frequencies at different polarizations can be selectively blocked. For example, f3 could be blocked in both polarizations if the switches 116 are closed on the bottom layer 82 on all four walls. Only for f3 will the all the layers appear as conductive layers, cutting off transmission at f3. If the shorting switches

116 are closed on the bottom layer 82 on the top and bottom walls 73, 75 only, transmission of the horizontally polarized signal at f3 is blocked, while still transmitting the vertically polarized signals at f3. If the switches 116 are closed on the bottom layer 82 on the sidewalls, transmission of the vertically polarized signal at f3 is blocked. By selectively closing the switches 116 at the other layers 84, 86, the different frequencies in different polarizations can be blocked.

Switching Mechanisms

The shorting switches used to short the conductive strips can employ many different known switches, with the preferred switches using micro electromechanical system (MEMS) technology or varactor layer diode technology. MEMS switches are generally described in Yao and Chang, "A Surface Micromachined Miniature Switch For Telecommunication Applications with Signal Frequencies from DC up to 4 Ghz," In Tech. Digest (1995), pp. 384-387 and in U.S. Patent No. 5,578,976 to Yao, which is assigned to the same assignee as the present application. U.S. Patent No. 5,578,976 to Yao, also discloses and discusses the design trade-offs in utilizing MEMS technology and the fabrication process for MEMS switches.

FIGs. 11, 12 and 23, show one embodiment of the MEMS shorting switches 112 constructed in accordance with the present invention to short the conductive strips 114 in the high impedance structure 110. The switches 112 are fabricated using generally known micro fabrication

techniques, such as masking, etching, deposition, and lift-off. FIG. 11 is a sectional view of the high impedance structure 110 taken transverse to the conductive strips 114. FIG. 12 is a sectional view taken long sectional lines one of the shorting switches 112. Both show high impedance structure's dielectric material 116, vias 118 and conductive layer 120.

The switches 112 are manufactured by depositing semiconductor layer 120 over the conductive strips 114 and over the exposed surface of the dielectric material 116, the preferred semiconductor material being Si_3N_4. Stand-off isolators 122 are deposited at intervals down the gap between the conductive strips 114 and are preferably formed of an insulator material such as silicon dioxide. A respective strip of metallic material 124 is mounted over each of the gaps by affixing it on the top of the stand-offs 122 along one of the gaps.

In operation, each metallic strip 124 has either 0 volts or voltage potential applied, with the preferred potential being 50 volts. With 0 volts applied, the strips 114 remain suspended above their respective gap between the stand off isolators 122 as shown in FIG. 12. The switches are in the "Off" state and the structure 110 presents as a high impedance to the design frequency E field transverse to the conductive strips 114. The gaps between the strips 114 presents a capacitance and the vias 118 present an inductance, with the structure presenting as a series of resonant L-C circuits to the transverse E field.

Referring now to FIG. 13, to close the switch 112 and short the gap between conductive strips 114 a 50 volt potential is applied to the metallic strips 124. This

causes an electrostatic tension between the metallic strips 124 and the respective conductive strips 114 below, pulling the switch strip down such that it makes capacitive contact with the strip 114 on each side of the gap. This provides a conductive bridge across the gap, shorting the gap. With all the metallic strips 124 pulled to the strips 114 below, the high impedance structure appears as a conductive surface to the signal's E field. This switching network consumes very little and has a very fast closure time on the order of 30 μs.

FIG 14 shows a high impedance structure 140 with a second embodiment of the shorting switches 142 that utilize varactor diode technology to short the gaps. The varactor diode is an ordinary junction diode that relies on its voltage dependent capacitance. Each varactor switch includes a N+ (highly conducting) layer 144 grown or deposited in the each gap between the conductive strips 146. An N- (moderately conducting) layer 148 is grown on top of top of a portion of the N+ layer 144.

In fabricating the switches 142, the N+ and N- layers 144 and 148 are etched into mesas that will provide a strip of varactor material along the length of the gaps between the conductive strips 146. The switching of the varactor is controlled by a second conductive strip 150 sitting on an insulator layer 152 that is sandwiched between the second strip 150 and each conductive strip 146. The insulator layer 152 provides a capacitive coupling to conductive strip 146 and the ground plane. Voltage applied to the second strip 150 controls the capacitance of the varactor layer and thus the shorting of the gap.

The presence of zero voltage on the varactor layer creates a high capacitance at the gap, virtually shorting (closing) the gap. This causes the high impedance structure

to appear as a conductive surface, cutting off transmission of the signal and making the shutter switch appear opaque. When a high voltage is applied to the varactor the capacitance at the gap is reduced. The high impedance structure is then resonant at the operating frequency and the waveguide will transmit the beam. With all its waveguides transmitting, the shutter switch appears transparent to the incident beam.

FIG. 15 shows millimeter beam transmission system 150 used in various high frequency applications such as munitions guidance systems (e.g. seeker radar). A transmitter 152 generates a millimeter signal 154 that spreads as it moves from the transmitter. Most of the signal is directed toward a lens 156 that collimates the signal into a beam 157 with little diffraction. The collimated beam travels to a second lens 158 that focuses the beam to a receiver 160. The shutter switch 162 is positioned between a millimeter wave transmitter 152 and receiver 160 such that it intercepts the transmission beam 157. When the shorting switches on the shutter switch's waveguides are open, the shutter switch 162 is transparent to the beam and the signal passes from the transmitter 152 to the receiver 160. When the shorting switches are closed, transmission of the signal through each of the waveguides is cut-off, making the shutter switch 162 opaque to the beam 157 and blocking transmission from the transmitter to the receiver.

As described above, when the waveguides in the shutter switch 162 have the high impedance structure on the sidewalls and the top and bottom walls, the beam can have horizontal and vertical polarization and the shutter switch 162 can block one or both of the polarizations. When the high impedance structure has multiple layers, the shutter

switch can be transparent or block signals at multiple frequencies and at one or both polarizations.

Although the present invention has been described in considerable detail with reference to certain preferred configurations thereof, other versions are possible. The waveguides in the shutter switch can have different high impedance structures and the new shutter switch can be used in other applications. Therefore, the spirit and scope of the appended claims should not be limited to their preferred versions describes therein or to the embodiments in the above detailed description.

I CLAIM:

1. A shutter switch for an electromagnetic wave beam, comprising:

a plurality of waveguides adapted to receive at least part of an electromagnetic beam, said waveguides being adjacent to one another with their longitudinal axes aligned with the propagation of said beam said waveguides switchable to either transmit or block transmission of their respective portions of said beam.

2. The shutter switch of claim 1, wherein each of said waveguides comprises:

four wall surfaces comprising two opposing sidewalls and a top and bottom wall;

respective high impedance wall structures on at least two opposing walls, said wall structures presenting a high impedance to E fields transverse to the waveguide axis and parallel to the wall structure, and a low impedance parallel to the waveguide axis; and

shorting switches on each said wall structures to short circuit their high impedances;

each of said waveguides having dimensions to cut-off the transmission of its respective portion of said beam when its high impedance wall structure is short circuited.

3. The shutter switch of claim 2, wherein each said high impedance wall structure comprises:

a sheet of dielectric material having two sides;

a conductive layer on one side of said dielectric material;

a plurality of mutually spaced conductive strips on

the other side of said dielectric material, said strips having gaps between adjacent said strips; and

a plurality of conductive vias extending through said dielectric material between said conductive layer and said conductive strips.

4. The shutter switch of claim 3, wherein said conductive strips have a uniform width and are disposed with a uniform gap between adjacent strips.

5. The shutter switch of claim 3, wherein adjacent pairs of said strips present a capacitance and said dielectric sheet presents an inductance to an electromagnetic beam with an E field transverse to said conductive strips.

6. The shutter switch of claim 5, wherein said conductive strips and dielectric material form a series of L-C circuits to an electromagnetic beam with an E field transverse to said conductive strips.

7. The shutter switch of claim 3, wherein said sheet of dielectric material comprises plastic, poly-vinyl carbonate (PVC), ceramic or high resistant semiconductor material.

8. The shutter switch of claim 3, wherein said high impedance structure are provided on said waveguide's sidewalls and present a high impedance to the E field component of a horizontally polarized beam.

9. The shutter switch of claim 3, wherein said high impedance structure are provided on said waveguide's top and bottom walls and present a high impedance to the E field component of a vertically polarized signal.

10. The shutter switch of claim 3, wherein said high impedance structure are provided on said waveguide's sidewalls and top and bottom walls and present a high impedance to the E field component of both horizontally and vertically polarized beams.

11. The shutter switch of claim 3, wherein said shorting switches change said high impedance structure to a conductive surface by shorting said gaps between said conductive strips.

12. The shutter switch of claim 11, wherein said shorting switches comprise micro electromechanical systems (MEMS) switches.

13. The shutter switch of claim 12, wherein each of said MEMS shorting switches comprises a shorting strip suspended over said gap between a respective pair of said conductive strips, said switch being closed by applying a voltage potential to said shorting strip creating an electrostatic tension between it and its respective conductive strips that pulls said shorting strip down to said conductive strips to form a conductive bridge across said gap between said conductive strips.

14. The shutter switch of claim 11, wherein said shorting switches comprise varacter diode switches in each of said gaps.

15. The shutter switch of claim 14, wherein each of said varactor diode shorting switches creates a high capacitance across its respective said gap when a zero voltage applied

to said diode to short said gap.

16. The shutter switch of claim 2, wherein said high impedance wall structure comprises:

a plurality of stacked high impedance layers, each presenting a high impedance to the E field component of a different respective electromagnetic beam frequency and being transparent to the E fields of lower frequency signals, and presenting a conductive surface to the E field of higher frequency signals; and

the bottommost said layer presenting a high impedance to the E field of the lowest frequency of said signals, and each succeeding layer presenting a high impedance to the E field of successively higher frequencies.

17. The shutter switch of claim 16, wherein each of said high impedance layers comprises a substrate of dielectric material having a top and bottom surface and a plurality of conductive strips on said substrate's top surface with gaps between adjacent conductive strips, and further comprising a conductive layer on the bottom surface of the bottommost layer's dielectric substrate.

18. The shutter switch of claim 16, wherein corresponding conductive strips of said high impedance layers are vertically aligned and said high impedance layers further comprise conductive vias through said dielectric substrates between said aligned conductive strips and said conductive layer.

19. The shutter switch of claim 16, wherein said conductive strips on each said layers have uniform widths and uniform gaps between adjacent strips.

20. The shutter switch of claim 16, wherein each of said high impedance layers presents a series of resonant L-C circuits to the E field of its respective signal frequency.

21. The shutter switch of claim 16, wherein the widths of said strips decreases and the width of said gaps between adjacent conductive strips increases with succeeding high impedance layers from the bottommost layer to the topmost.

22. The shutter switch of claim 16, wherein said high impedance wall structures are on said waveguide's sidewalls and present a high impedance to the E field component of said different frequency beams having horizontal polarization.

23. The shutter switch of claim 16, wherein said high impedance wall structures are on said waveguide's top and bottom walls and present a high impedance to the E field component of said different frequency beams having vertical polarization.

24. The shutter switch of claim 16, wherein said high impedance structures are on said waveguide's sidewalls and top and bottom walls and present a high impedance to the E field component of said different frequency beams having both horizontal and vertical polarizations.

25. The shutter switch of claim 16, wherein said shorting switches change said high impedance structure to a conductive surface by shorting said gaps between said conductive strips.

26. The shutter switch of claim 25, wherein said shorting switches comprise micro electromechanical systems (MEMS) switches.

27. The shutter switch of claim 25, wherein each of said MEMS shorting switches comprises a shorting strip suspended over said gap between a respective pair of said conductive strips, said switch being closed by applying a voltage potential to said shorting strip creating an electrostatic tension between it and its respective conductive strips that pulls said shorting strip down to said conductive strips to form a conductive bridge across said gap between said conductive strips.

28. The shutter switch of claim 25, wherein said shorting switches comprise varacter diode switches in each of said gaps.

29. The shutter switch of claim 28, wherein each of said varactor diode shorting switches creates a high capacitance across its respective said gap when a zero voltage applied to said diode to short said gap.

30. The shutter switch of claim 25, wherein said shorting switches are closed on selective layers of said high impedance structures to block transmission one or both polarities of said beam at one or all of said different frequency signals.

31. A millimeter beam transmission system, comprising;

an electromagnetic beam transmitter;

an electromagnetic beam receiver;

a shutter switch positioned in the path of said beam

between said transmitter and receiver, said shutter switch comprising at least one waveguide positioned to receive at least part of said beam, the longitudinal axis of each of said waveguides aligned with the propagation of said beam, each of said waveguide being switchable to either transmit or block transmission of its respective portion of said beam.

32. The system of claim 31, wherein said beam transmitter comprises a radiating element for generating a electromagnetic millimeter signal and a first lens positioned to collimate at least part of said millimeter signal into a beam, and said ~~receive~~ receiver comprises a electromagnetic receiving element and a second lens positioned to focus said beam to said receiving element, said shutter switch positioned between said first and second lenses.

33. The system of claim 31, wherein each said waveguide comprises

four wall surfaces comprising two opposing sidewalls and a top and bottom wall;

a high impedance wall structure on at least two opposing walls of said waveguide, said wall structure presenting a high impedance to E fields transverse to the waveguide axis and parallel to the wall structure, and a low impedance parallel to the waveguide axis; and

shorting switches on each said high impedance structure to change the high impedance of said structure to a conductive surface.

34. The system of claim 33, wherein each said waveguide has

dimensions such that the transmission of said electromagnetic beam is cut-off when said waveguide sidewalls and top and bottom walls are conductive surfaces.

35. The system of claim 33, wherein each said high impedance wall structure comprises:

a sheet of dielectric material having two sides;

a conductive layer on one side of said dielectric material;

a plurality of mutually spaced parallel conductive strips on the other side of said dielectric material; and

a plurality of conductive vias extending through said dielectric material between said conductive layer and said conductive strips.

36. The system of claim 35, wherein said conductive strips have a uniform width, are disposed with a uniform gap between adjacent strips and are parallel to the longitudinal axis of their respective said waveguide.

37. The system of claim 36, wherein said conductive strips, vias and dielectric material form a series of L-C circuits to an electromagnetic wave with an E field transverse to said conductive strips.

38. The system of claim 36, wherein said shorting switches change said high impedance structure to a conductive surface by shorting said gaps between said conductive strips.

39. The system of claim 33, wherein said high impedance wall structure comprises:

a plurality of stacked high impedance layers, each

presenting a high impedance to the E field component of a different respective electromagnetic beam and being transparent to the E fields of lower frequency signals, and presenting a conductive surface to the E field of higher frequency signals; and

the bottommost said layer presenting a high impedance to the E field of the lowest frequency of said signals, and each succeeding layer presenting a high impedance to the E field of successively higher frequencies.

40. The system of claim 39, wherein each said layer presents a series of resonant L-C circuits to the E field of its respective signal frequency.

41. The system of claim 39, wherein each of said high impedance layers comprises a substrate of dielectric material having a top and bottom surface and a plurality of conductive strips on said substrate's top surface, and further comprising a conductive layer on the bottom surface of the bottommost layer's dielectric substrate.

42. The system of claim 39, wherein corresponding conductive strips of said layers are vertically aligned and said high impedance structure further comprises conductive vias through said dielectric substrates between said aligned conductive strips and said conductive layer.

43. The system of claim 39, wherein said shorting switches change said high impedance structure to a conductive surface by shorting said gaps between said conductive strips.

44. The system of claim 33, wherein said high impedance

structure are provided on said waveguide's sidewalls and present a high impedance to an E field component of horizontally polarized beams at one or more frequencies.

45. The system of claim 33, wherein said high impedance structure are provided on said waveguide's top and bottom walls such that said high impedance structure and present a high impedance to an E field component of a vertically polarized beams at one or more frequencies.

46. The system of claim 33, wherein said high impedance structures are provide on said waveguide's sidewalls and top and bottom walls and present a high impedance to the E field component of a horizontally and vertically polarized beams at one or more frequencies.

47. The system of claim 46, wherein said shorting switches are closed on selective layers of said high impedance structures to block transmission one or both polarities of said beam at one or all of said different frequency signals.

48. A method of switching an electromagnetic beam, comprising:

transmitting said beam through one or more waveguides; and

switching the walls of said waveguides between high impedance and conductive states to control the propagation of selected modes of said beam.

49. The method of claim 48, wherein said electromagnetic beam is horizontally polarized and switching the sidewalls of said waveguides between high impedance and conductive

states controls the propagation of said beam.

50. The method of claim 48, wherein said electromagnetic beam is vertically polarized and switching the top and bottom walls of said waveguides between high impedance and conductive states controls the propagation of said beam.

51. The method of claim 48, wherein said electromagnetic beam is horizontally and vertically polarized and switching the walls of said waveguides between high impedance and conductive states controls the propagation of said beam.

52. The method of claim 48, wherein said electromagnetic beam is horizontally and vertically polarized, and has different frequencies, the switching of the walls between high impedance and conductive states controls propagation of said beam at different frequencies and polarizations.

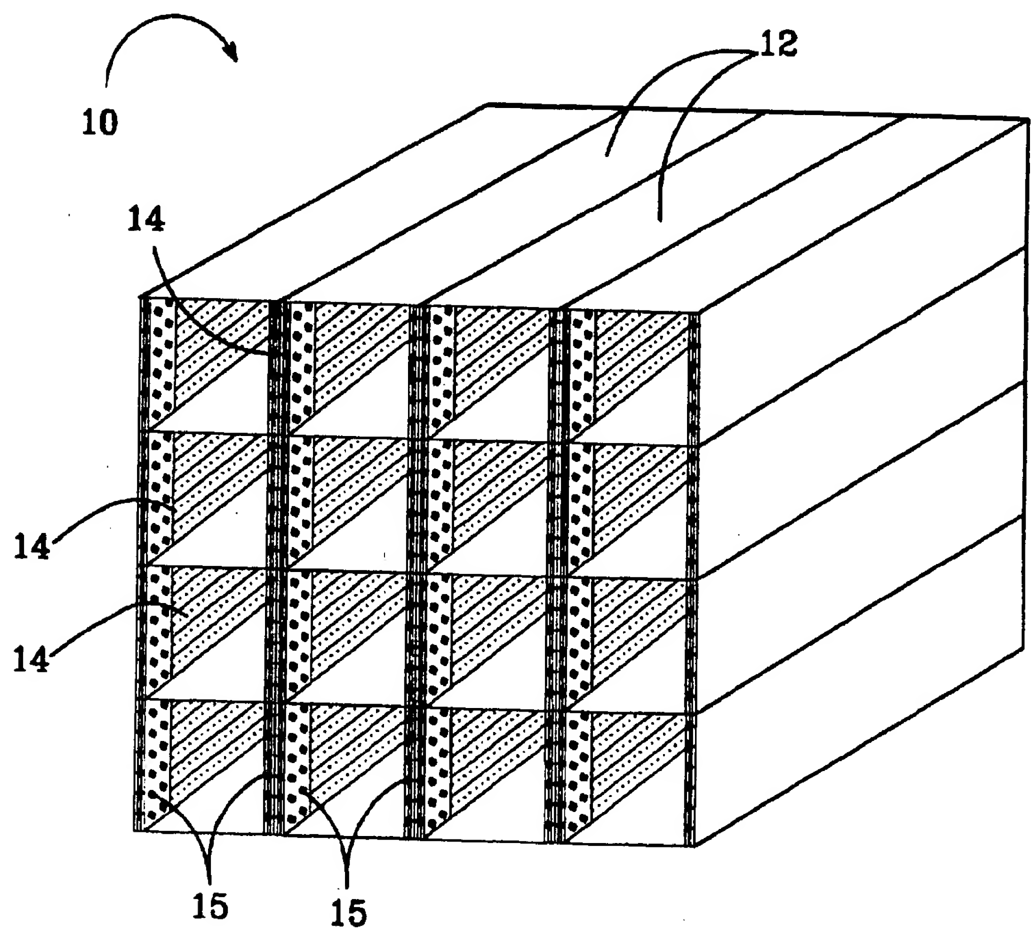

FIG.1

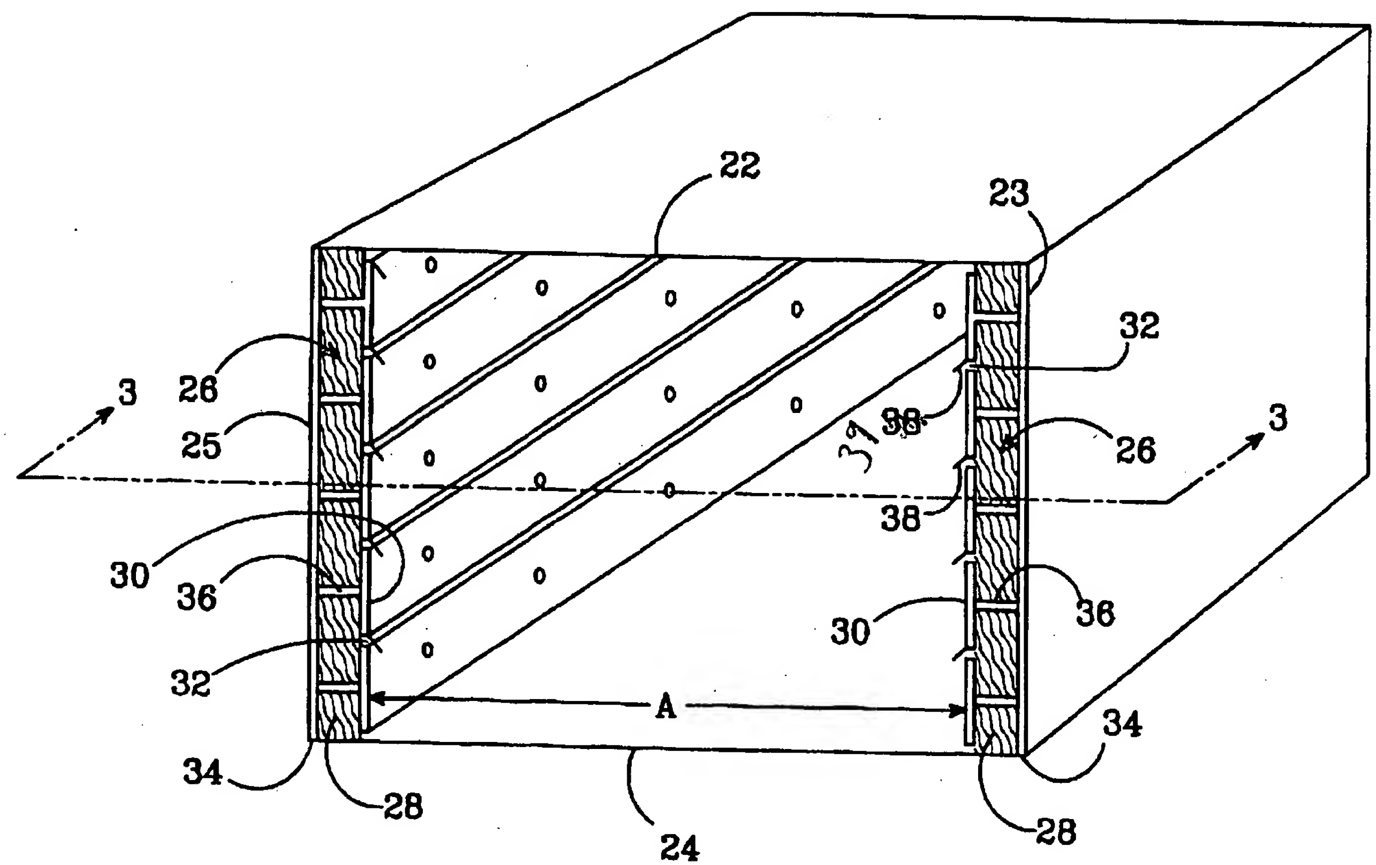

FIG.2

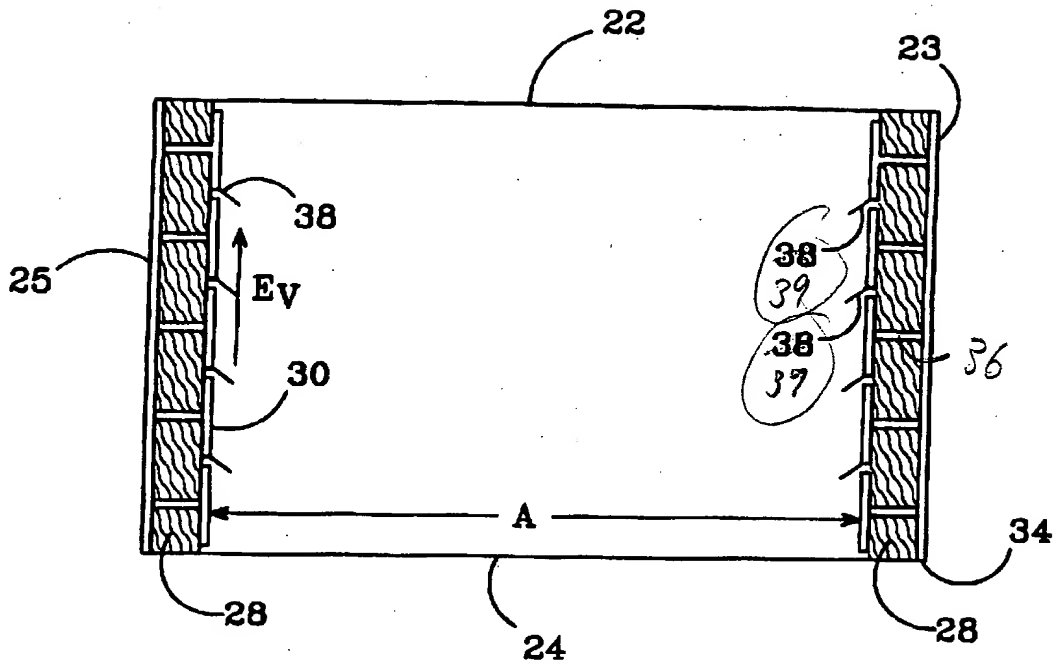
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FIG.3

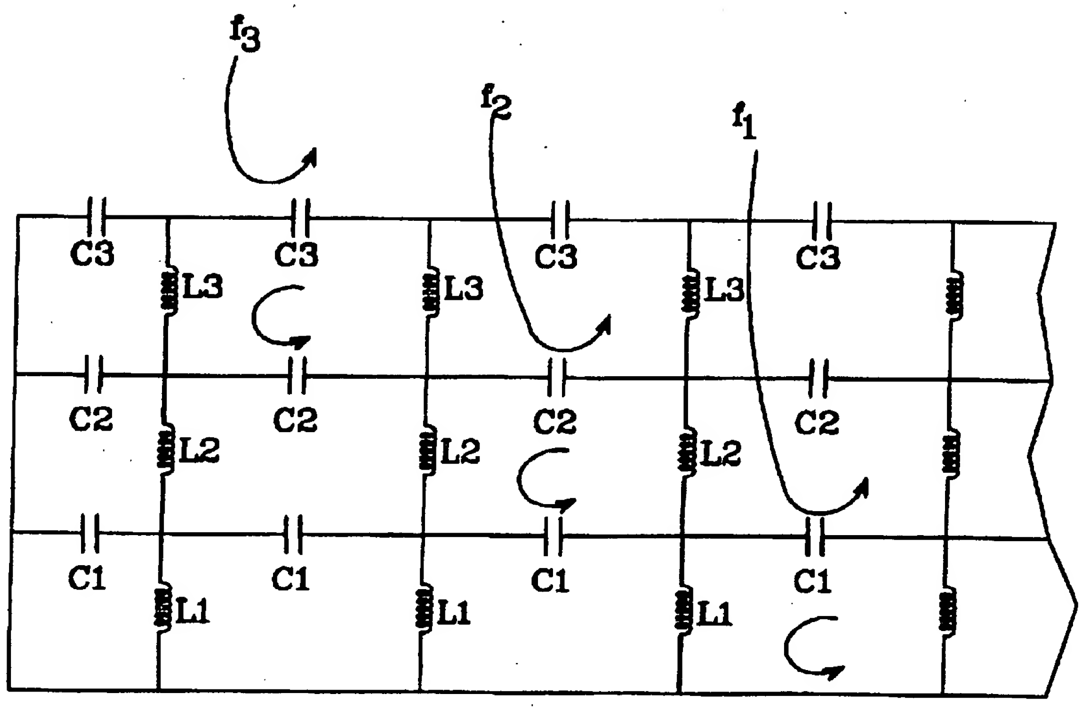
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FIG.9

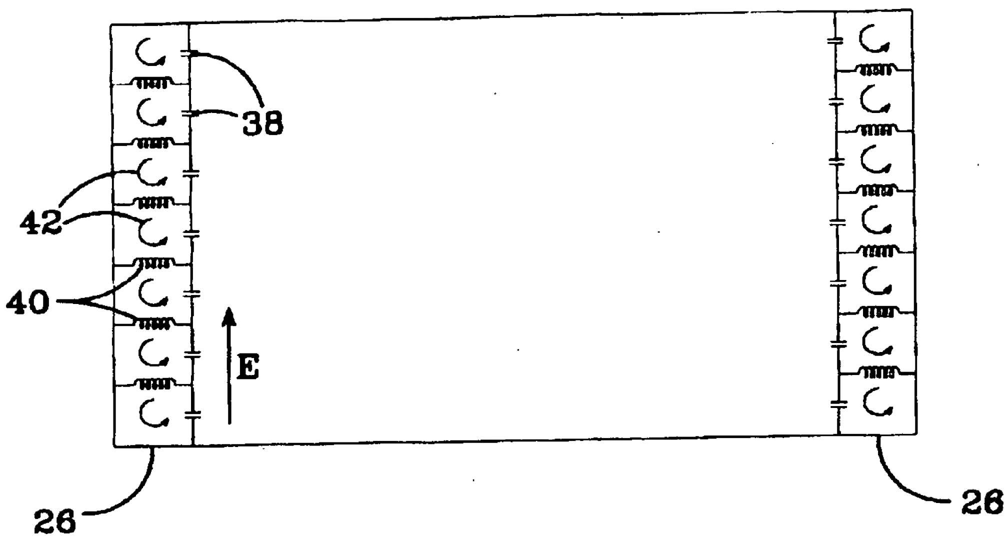


FIG.4

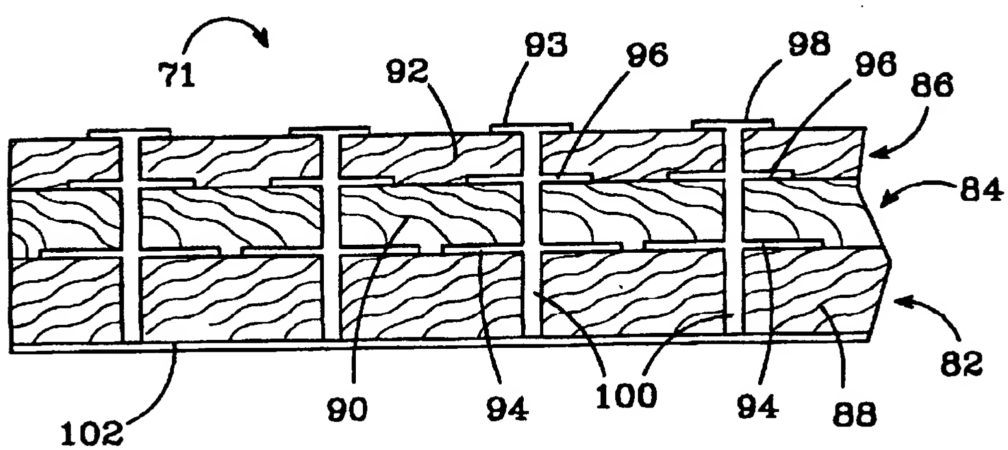
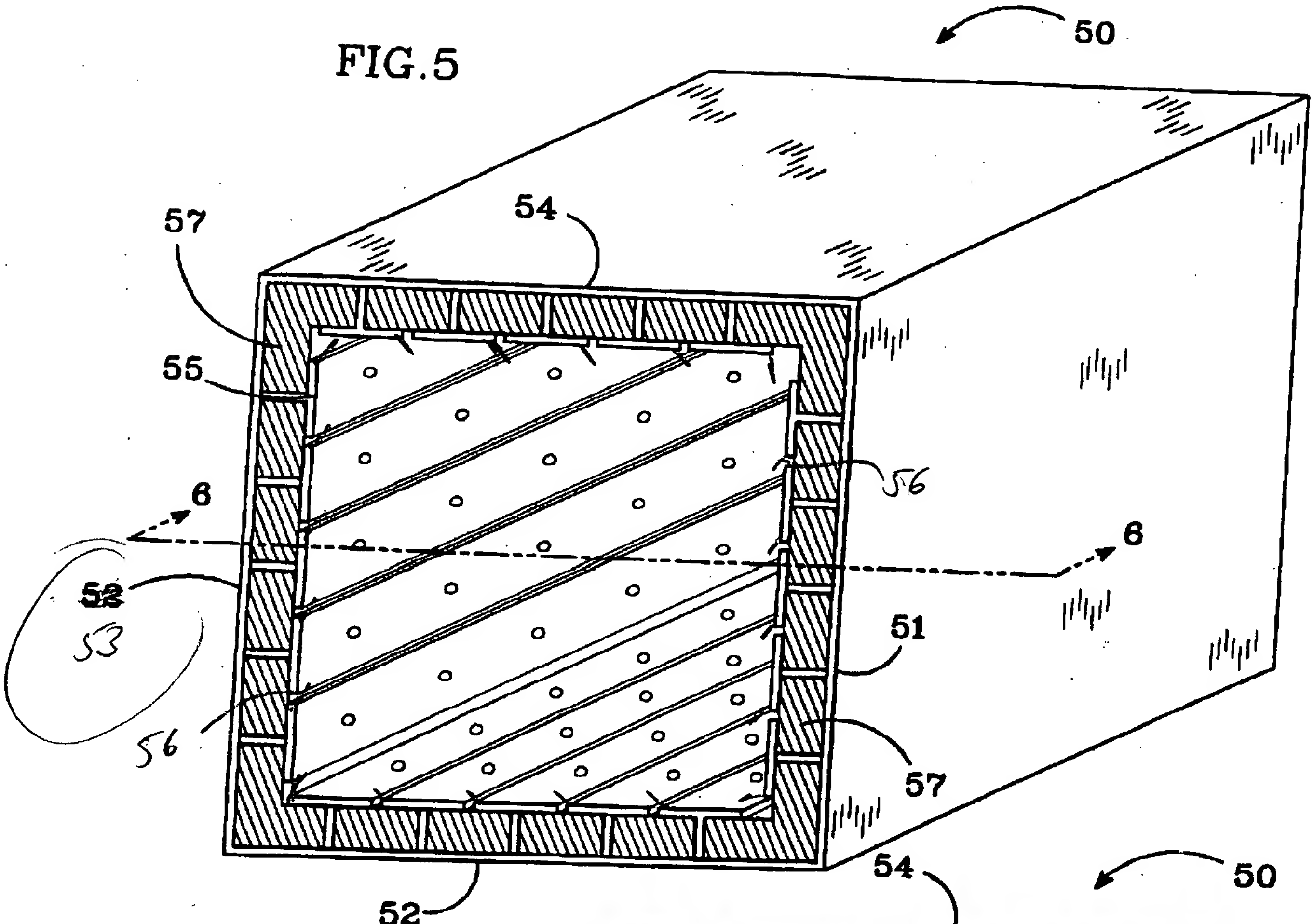


FIG.8

FIG.5



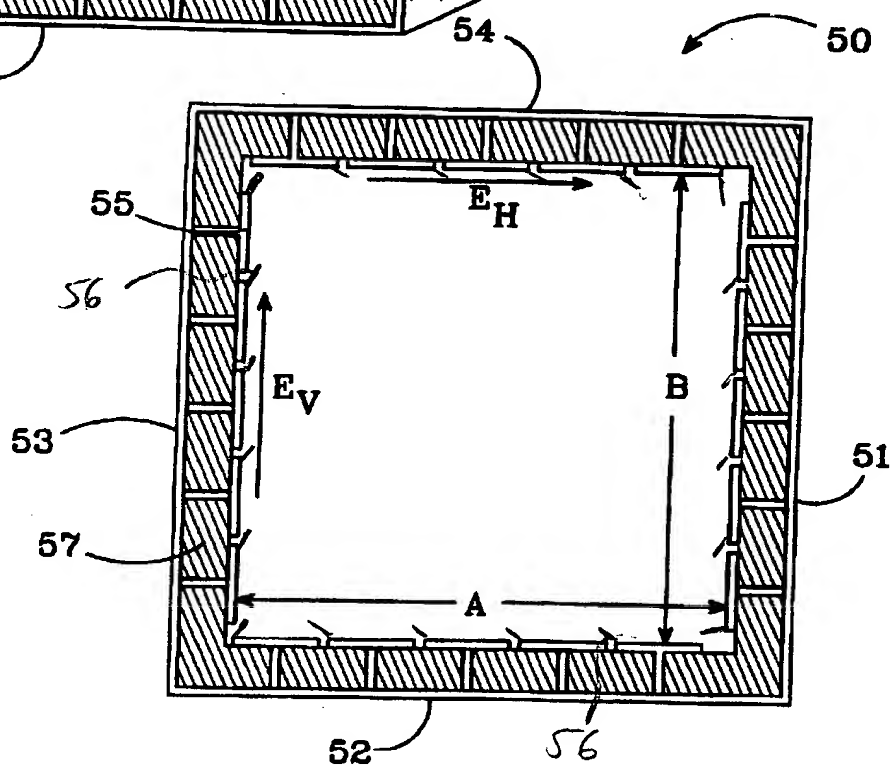


FIG.6

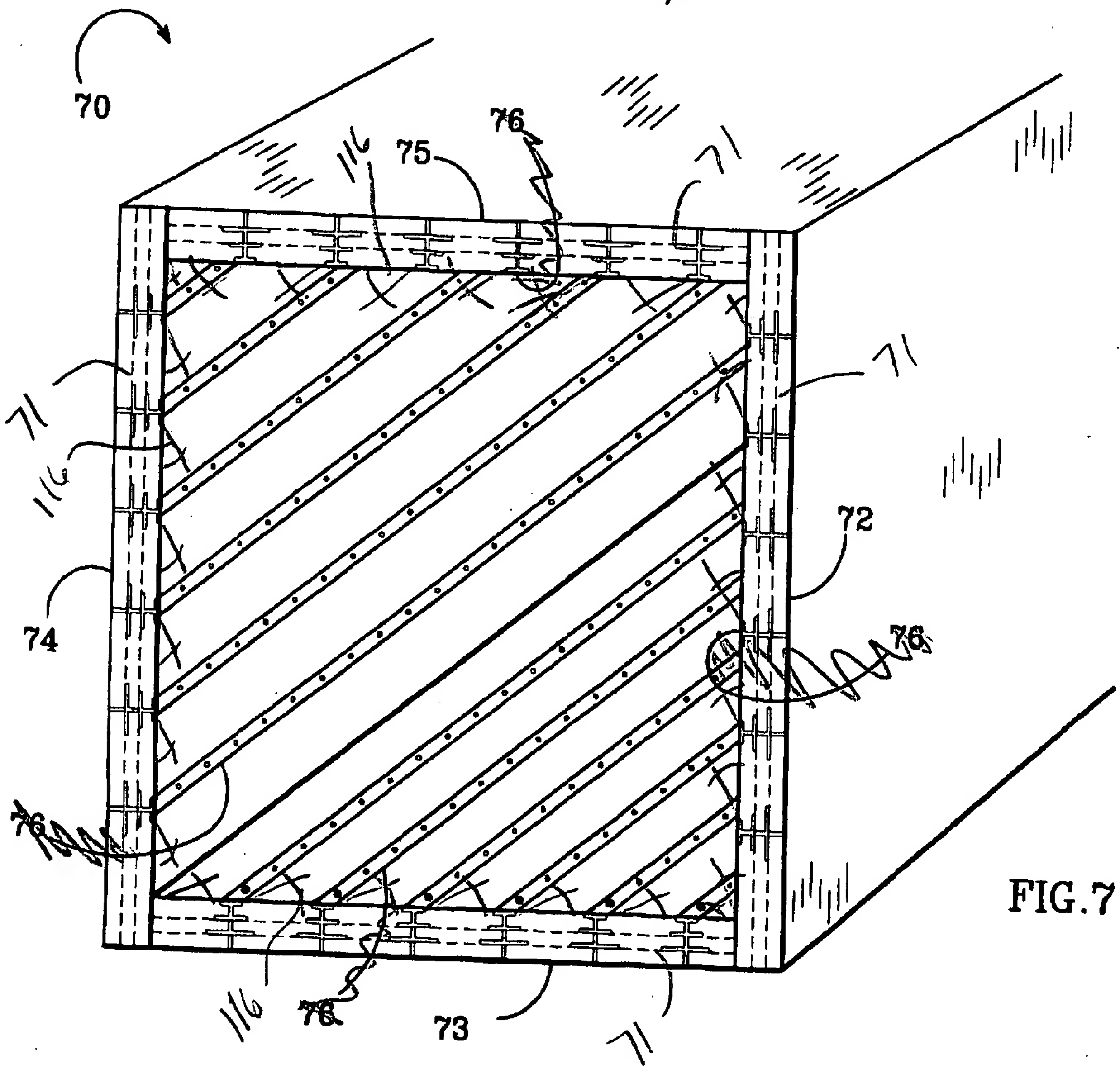


FIG.7

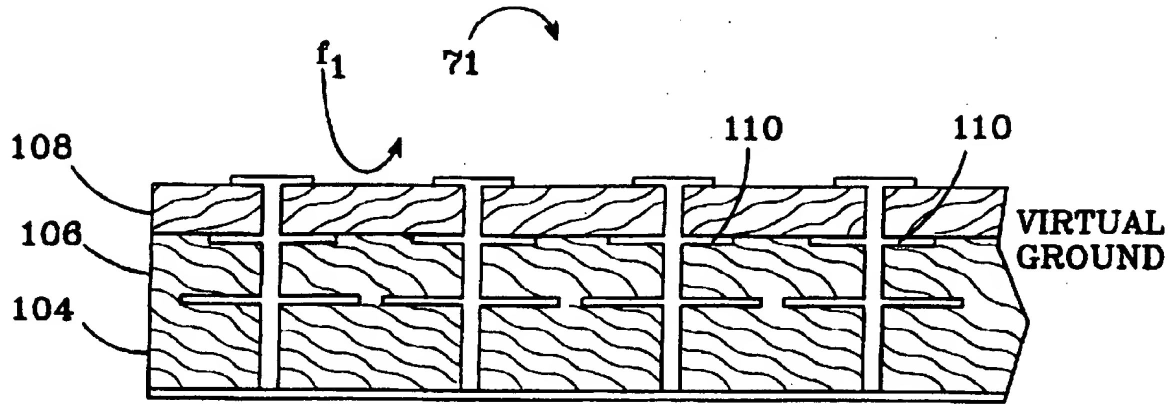


FIG.10a

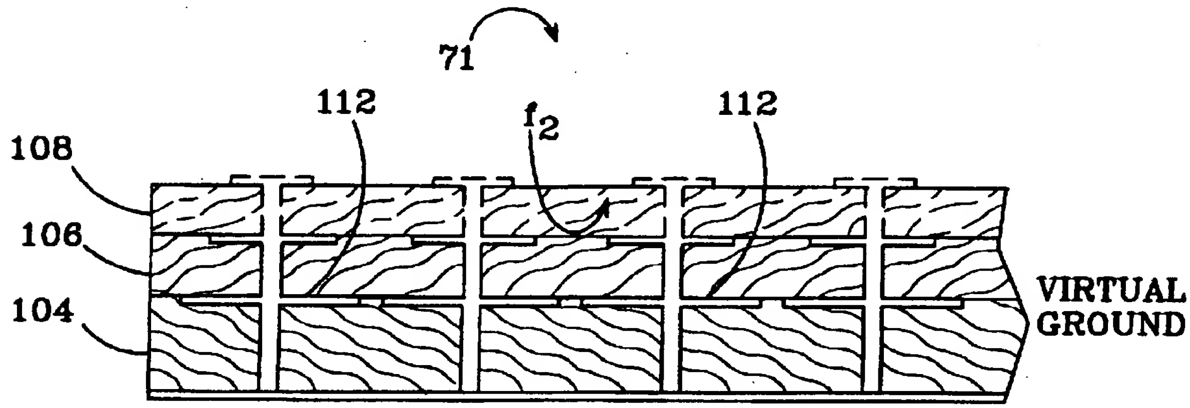


FIG.10b

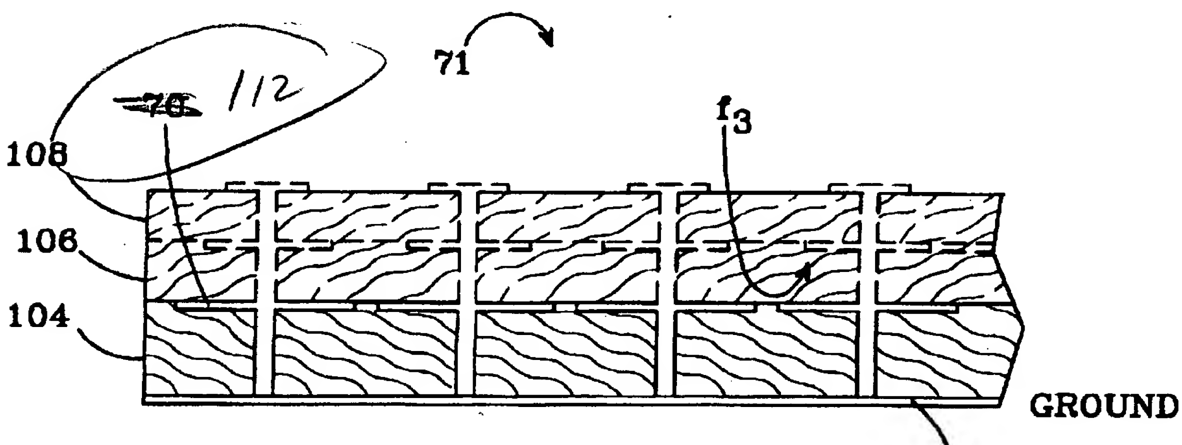


FIG.10c

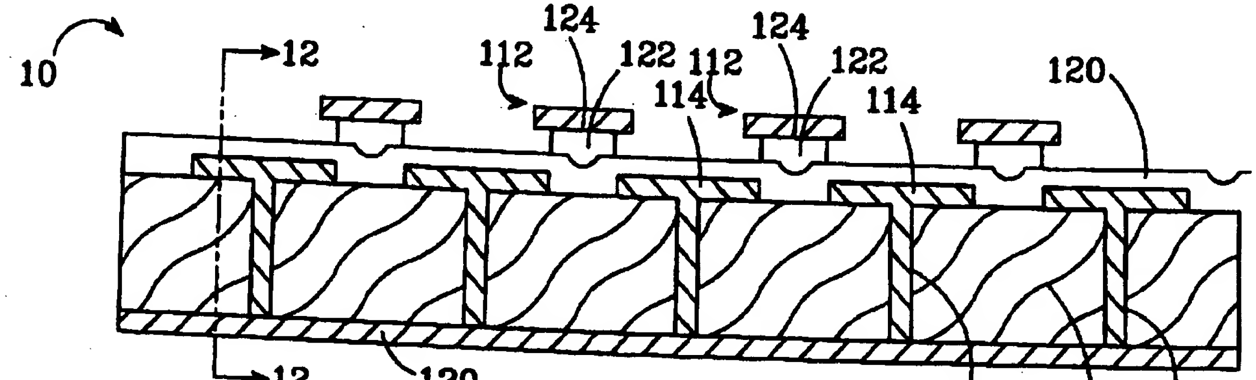


FIG.11

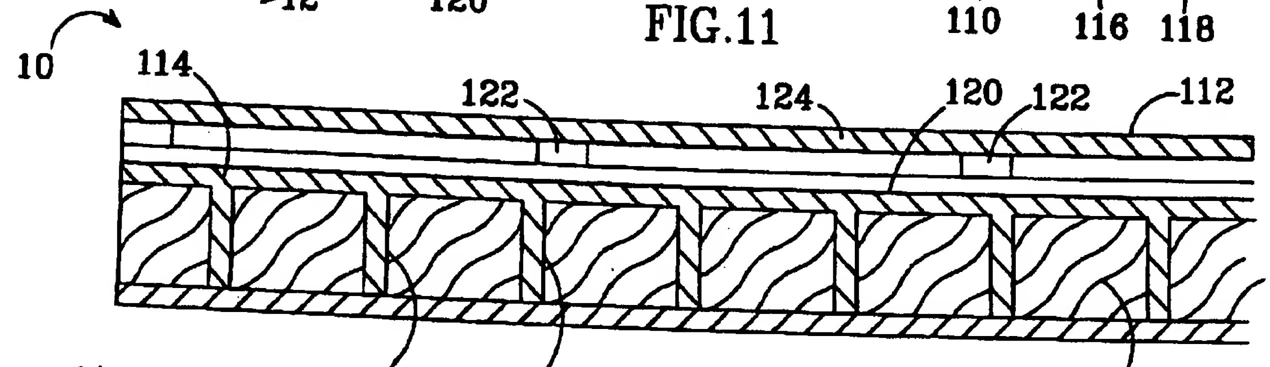


FIG.12

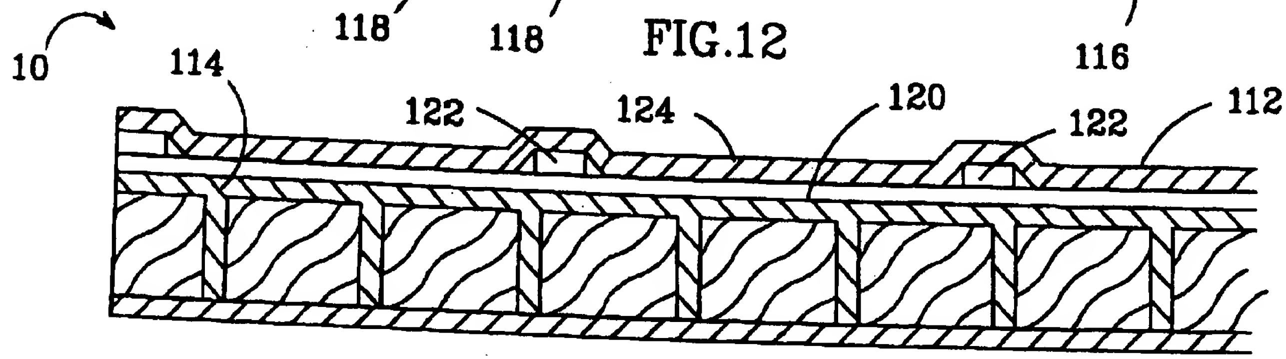


FIG.13

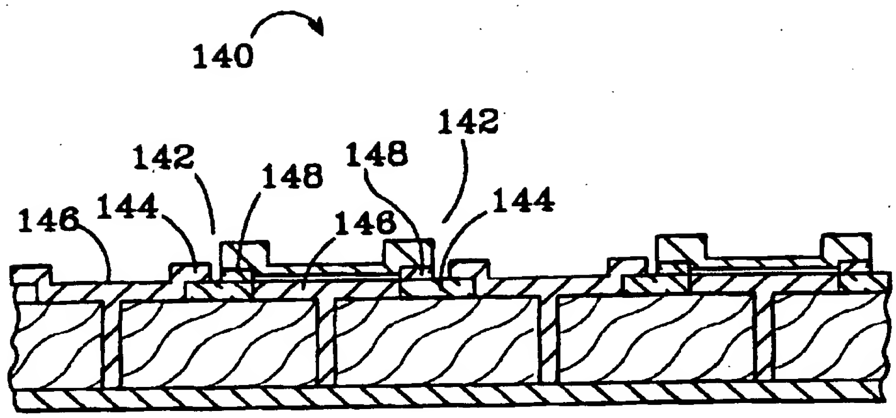

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FIG.14

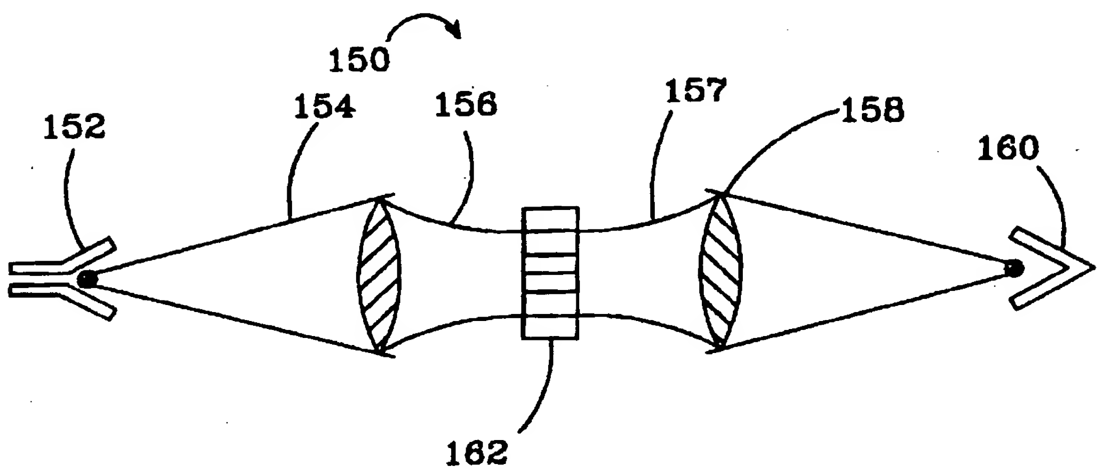
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FIG.15